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THE EARLY EMBRYOLOGICAL DEVELOPMENT OF THE PARTHENOGENETIC ALFALFA SNOUT BEETLE, BRACHYRHINUS LIGUSTICI L.

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The alfalfa snout beetle, *Brachyrhinus ligustici*, is an introduced pest which probably came about forty years ago from central Europe where it is widely distributed, but was not much of a problem in this country until alfalfa growing became extensive within the past few years. It was discovered about 1933 to be feeding on alfalfa near Oswego, New York. The adult is wingless, which probably accounts for the fact that it has spread so slowly and is confined to a comparatively small area around Oswego (Palm, 1935). However, it develops in very large numbers in small restricted areas and does serious damage to alfalfa.

Vassiliev (1909) in Russia, isolated pupae of *Brachyrhinus ligustici* and reared three generations of beetles from them without the appearance of males thus demonstrating that this insect reproduces parthenogenetically. His work was preceded by that of Ssilantjew (1906) and followed by Smith (1932) who, working with several other species of Brachyrhinus, obtained the same results. Vassiliev's investigations of *Brachyrhinus ligustici* were confirmed during the summer of 1934 by Charles E. Palm, of the Cornell University Experiment Station, but the cytological details of its reproduction have never been studied. Consequently, this investigation was undertaken at the suggestion of Professors O. A. Johannsen and C. R. Crosby, of Cornell University, to determine the method of parthenogenetic reproduction and also to make as complete an outline as the materials at hand would permit of the embryology of a snout beetle, an insect belonging to a group that has received little attention in the initial stages of its development.

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METHODS

The location of the infestation from which material was taken was at the field station of the Cornell University Experiment Station established by Mr. Palm during the spring of 1934 on the Wadsworth farm near Oswego. The eggs apparently are laid in the upper two inches of soil near alfalfa plants or in alfalfa seedings. They are deposited from the latter part of May until after the middle of July, the height of oviposition occurring through the latter half of June (Palm, 1935). In order to obtain eggs at timed intervals, six or seven beetles were placed in a covered jelly glass in which about half an inch of sand and fresh alfalfa foliage had been placed. Only ten or twelve of these laying cages were made up as it was found that more than that could not be handled easily. Every fifteen minutes for two hours the sand in each of the glasses was sifted and the eggs placed in salve boxes on black paper kept moist by wet blotting paper underneath. Eggs were then sifted out at half-hour intervals for the next twenty-two hours. For more advanced stages where exact age was unimportant, siftings were made at longer intervals. Only a few eggs were obtained in a single sifting during the early stages, but when the beetles were left undisturbed for an hour, as many as thirty eggs at a time would be obtained. Consequently, several different series were sifted to get enough material with which to work.

Eggs were killed every fifteen minutes for the first five hours and every half hour thereafter for the remainder of the first day. From the twenty-fourth hour they were killed at hourly intervals with several gaps of three to four hours until the fourth day. From then on eggs were killed several hours apart so that there were on the average fifteen sets of eggs preserved for each twenty-four hours for seven days and about half that number for succeeding days until hatching time which occurred between the tenth and the thirteenth days.

The eggs were dropped in hot Dietrich's fluid (60° C.) allowed to remain until the fluid cooled slightly and then were punctured with a number ten needle to allow the fluid to penetrate the chorion. They were left in the fixing fluid for twenty-four hours or more and were stored in 85% alcohol.

Before the eggs were embedded they were stained in borax-carmine and the advanced stages were destained in acid 70% alcohol so that the eggs could be properly oriented in the block of paraffin. Several methods of embedding were tried. The paraffin-celloidin method of double embedding was found necessary for most of the stages especially when the embryonic envelopes were left on. If these were removed the embryo could be sectioned very easily when embedded in rubber-paraffin. A number of eggs were dehydrated with analine oil and butyl alcohol was also used for some of the later stages. Good sections were obtained with both methods even when the brittle embryonic envelopes were left on and the egg was embedded in rubber-paraffin only. Sections were cut at six microns for longitudinal and eight microns for cross sections.

THE EGG

The egg is in most cases oval in shape but sometimes almost spherical, averaging .85 mm. in length and .68 mm. in width. These measurements vary considerably, some eggs being as much as one mm. long. When laid, the egg is creamy white and is covered with a sticky substance to which the soil particles adhere. The presence of this sand made it necessary to remove the chorion in order not to injure the microtome blade. After the first day the color changes first to a dull yellow and gradually to a light brown. The yolk consists of globules of varying size which are surrounded by cytoplasm which, however, is not arranged as a reticulum at this time. Surrounding the yolk is a thin layer of cytoplasm, the periplasm which in some cases seems to consist of two layers, an outer that stains lighter than the inner layer. At the posterior pole of the egg an irregular saucer shaped disc can sometimes be seen lying partly in the periplasm and partly in the yolk. This is the germinal cytoplasm. It will be described in more detail in connection with germ cell formation. The vitelline membrane is difficult to make out and the chorion is so thin and elastic that it can easily be removed after being pricked with a needle.

TYPES OF PARTHENOGENETIC MATURATION

Among insects parthenogenesis is a fairly common phenomenon. It is well known that honey bee drones are produced from unfertilized females and possess only half the usual number of chromosomes found in the queen and workers. According to Sharp's (1926) classification, this is known as haploid parthenogenesis. There is also another type the diploid in which the chromosomes are not reduced in number. This type may be divided as follows: Those that reproduce with no maturation division; those that reproduce with one maturation division; and those that reproduce with two maturation divisions, without reduction in chromosome number.

The location of the pronucleus at the time of oviposition could not be determined with any degree of certainty. In several eggs prior to the formation of the polar bodies it was observed near one end of the egg. In others taken about three hours after oviposition, it was in the periphery about half way between the ends of the egg ready to throw off the polar body. In one egg killed fifteen minutes after it had been deposited, the polar body had just been thrown off and could be seen in the periphery with the nucleus, slightly toward the anterior pole from the middle of the egg (Plate I, 1). It is probable therefore, that the pronucleus migrates to the anterior pole, then back to the periphery nearly half way between the poles where the polar body is formed. The variation in time of polar body formation is due probably to variations in conditions such as temperature or humidity which cause one batch of eggs to differ from another.

A marked thickening occurs in the peripheral cytoplasm surrounding the pronucleus. This has been noticed by other workers and has been called the richtungsplasma or polar plasm. In some eggs a de-

pression forms on the surface at the point of this thickening. The polar body is given off in this polar plasm and the nucleus immediately migrates back into the yolk of the egg without giving off a second polar body (Text Fig. A). Immediately after the polar body has divided from the pronucleus, the chromosomes appear distinct enough to indicate that there is no reduction in number. In several cases there were about twenty-five chromosomes in both the nucleus and polar body. Later counts made in cleavage nuclei that were migrating into the periphery during blastoderm formation confirmed this number as being equal to the somatic number of chromosomes.

Therefore, it is evident that *B. ligustici* belongs to that group of insects that reproduce with only one maturation division and without reduction in the number of chromosomes, the diploid type.

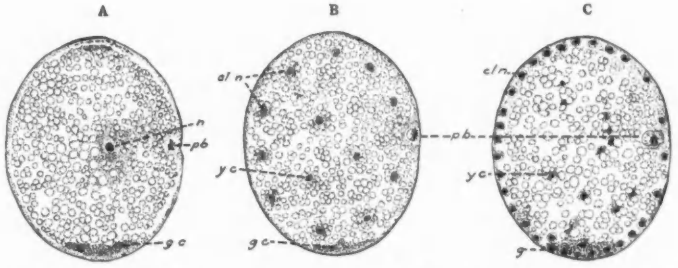

Fig. A. Mature egg showing nucleus, polar body, and germinal cytoplasm. B. Cleavage at eighteen hours. C. Cleavage at thirty hours.

CLEAVAGE STAGES

About the time the nucleus is again near the center of the egg the polar body divides and one of the resultant nuclei is pushed out into the cavity mentioned above, under the vitelline membrane and is entirely cut off from the cytoplasm (Plate I, 2). In the meantime the first cleavage division has taken place and the daughter nuclei are migrating toward the periphery. Between the ninth and the twelfth hours there are sixteen to thirty-two in the yolk. At eighteen hours the daughter nuclei have increased in number and have reached a point about two-thirds the distance towards the periphery (Text Fig. B). At the thirtieth hour they appear in the periphery but quite widely separated from one another (Text Fig. C). Each division during this migration has been synchronous but very few spindles were seen, most of the nuclei being in the prophase or in the resting stage. The division must take place very quickly in order to account for the uniform lack of the anaphase stage in this material.

During cleavage, the remaining polar body grows very large, several times the size of the cleavage nuclei. In all cases a nuclear wall to which the chromatin material tends to adhere can readily be seen. After the very earliest stages of polar body formation the chromosomes lose their characteristic form and appear simply as a large mass of

irregular threads, much more in quantity than in the nucleus (Plate I, 3). In some cases the polar body has been observed to divide but no spindles are formed, a large portion of the polar body splitting off and a mass of chromatin material passing from one part to the other. This does not always occur, however, the polar body sometimes remaining as a large vacuolated cell in which the chromatin material gradually disintegrates and disappears. This process extends over a considerable period of time. The polar body is still discernible in the yolk at thirty hours when the cleavage nuclei have already reached the periphery (Plate I, 3). At the thirty-two hour stage when there are many more cleavage nuclei in the periphery but before any cell walls have formed around them a large mass of cytoplasm still exists in the yolk but by this time the chromatin material has disintegrated almost entirely (Plate I, 4). The cleavage nuclei in the area nearest this last remnant of the polar body are not as numerous as in other regions of the periphery and no cell walls have begun to form although they are well along in development on the opposite side of the egg. This would indicate that as long as the polar body lasts its presence prevents the cleavage nuclei from entering the periphery.

FORMATION OF THE GERM CELLS AND VITELLOPHAGS

The germinal cytoplasm is an irregular mass of granular material located at the posterior pole of the egg. When stained with either iron haemotoxylin or Delafield's haemotoxylin it appears much darker than the rest of the cytoplasm of the egg. It may form a saucer-shaped disc lying between the yolk and the cytoplasm (Plate I, 7), or a smaller but very thick mass extending for some distance into the yolk (Plate I, 8). In either case it is not homogeneous but contains large globules or irregular bodies of material that stain much lighter and appear to be identical in composition with the peripheral cytoplasm. Yolk globules also are scattered through the germinal cytoplasm but not to the same extent as the lighter staining material.

As they approach the posterior pole some of the cleavage nuclei come into contact with the germinal cytoplasm which breaks up and gathers around them in large masses. They move on to the periphery but do not leave the walls of the forming blastoderm (Text Fig. C). They are the germ cells and their development from this point is entirely distinct from the other cleavage nuclei. The blastoderm cells, as they increase in number and acquire walls first on the outside, then on their lateral faces, become columnar in form except where they are interrupted by the germ cells and where they are retarded by the disintegrating polar body. Before the inner walls of the blastoderm have formed, the germ cells move inward to form a syncytium between the yolk and the blastoderm cells (Plate I, 4). When the cleavage nuclei move out from the center of the egg, several of their number are left behind (Text Fig. B) to become yolk cells. Others as they reach the germinal cytoplasm seem to gather up some of the material there but instead of continuing with the germ cells, wander back into the yolk where they become scattered (Text Fig. C). In several eggs I have noticed also a mass of dark staining granular material in the anterior

pole of the egg. It is not so extensive as the germinal cytoplasm but it may be that yolk cells move inward from the anterior pole carrying this material with them. Lassmann (1935), working with the sheep tick has observed that the yolk cells stream inward from both the anterior pole and the posterior pole near the region of the germ cells. A similar situation may exist in this species although not enough sections have been cut during this stage of development to indicate that such was definitely the case. A third source of yolk cells was the blastoderm itself. In nearly every slide a few cells were observed to be migrating back into the yolk (Plate I, 5).

BLASTODERM AND DORSAL ORGAN

When the inner walls of the blastoderm are complete, the blastoderm consists of a thick layer of closely packed columnar cells. The outer ends of these cells, between the nuclei and the periphery, stain dark while the inner ends are uniformly vacuolated. The primary dorsal organ appears at this time as a mass of cells that invaginate into the yolk along one side of the blastoderm leaving a groove on the outside surface (Plate I, 6). The groove is very short but the cellular invagination extends in a longitudinal direction for about one-tenth the length of the egg. The ridge of cells is capped by a dark staining granular mass of cytoplasm, the origin of which is not apparent in this material. As in Donacia (Hirschler, 1909) and Euryope (Patterson, 1932) the primary dorsal organ lasts but a short time. It appears when the blastoderm is complete at the thirtieth hour but disappears before the ventral plate has become enclosed by the amniotic folds.

FORMATION OF EMBRYONIC ENVELOPES AND DIFFERENTIATION OF THE VENTRAL PLATE

Stages that would show the formation of the ventral plate or embryo and its over-growth on the ventral side by the amniotic folds are lacking in my material. However, it is apparent that the differentiation of the ventral plate takes place about the thirty-fifth hour. It is probable that this process occurs in the alfalfa weevil in the same manner as in other Coleoptera since in other respects its development is typical.

Wheeler (1889), Hirschler (1909), and Patterson (1931–32), describe the start of the amniotic folds, which mark the edges of the ventral plate, as two ridges on the ventral side of the egg. Wheeler describes them as formed like two parentheses which fold over toward the mid line and grow together enclosing the ventral plate inside a double envelope. The inside envelope, the amnion, covers the ventral side of the embyro and is contiguous with its edges. The outside envelope, the serosa, consisting of all the remaining blastoderm, completely encloses all the contents of the egg and lies next to the vitelline membrane.

According to Korschelt and Heider (1899), the beetles are half way between those insects with an immersed germ band and those with the superficial type. Typically, then, the amnion at the posterior end of the ventral plate would be formed by the invagination of the tail into the yolk. At the anterior end, on the other hand, the head of

the embryo would remain at the surface and be overgrown by the anterior amniotic fold. In Euryope (Patterson, 1931) the germ band is formed superficially and does not penetrate the yolk until the tail end has reached the dorsal side; it then curls only slightly into the yolk. The same is true for other Chrysomelidae.

Brachyrhinus is closer to the invaginated type than is Euryope. The head end remains on the surface from the beginning and the tail pushes into the yolk. The earliest stages which should show this invagination are lacking in the material available for this study. However, it is apparent that the tail pushes into the yolk from the posterior pole of the egg until it lies on the dorsal side nearly touching the serosa. The ventral plate is drawn into the yolk by this invagination except for the head end which remains on the surface at the posterior end of the egg (Plate II, 12, and Text Fig. D).

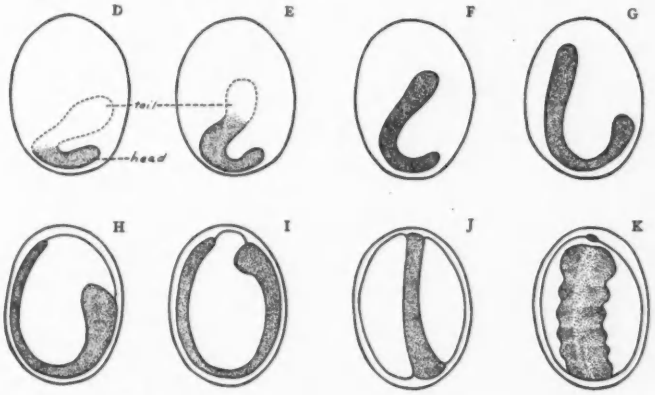

Fig. D. Tail of embryo invaginated into the yolk; head at the posterior pole of the egg. E. Embryo lengthening; tail withdrawing from the yolk in a lateral direction. F. Tail on the surface of the yolk. G. Tail lengthening and returning to the dorsal side. H. and I. Lengthening of embryo until head and tail nearly erect. J. Dorsal view showing tail at start of segmentation. K. Ventral view of same egg showing segmentation in head region.

The embryo now begins to lengthen and at the same time to withdraw from the yolk. It withdraws in a lateral direction so that if the egg is viewed in a whole mount from one side, the embryo appears somewhat S-shaped with the tail still immersed in the yolk (Text Fig. E). When the withdrawal process is complete, the tail lies diagonally over the side of the yolk while the head and the fore part of the embryo still lie in a vertical plane at the posterior pole of the egg (Text Fig. F). As the tail grows toward the anterior pole it has a tendency to return to the mid-dorsal line (Text Figs. G, H). In the meantime the head has grown along the ventral side of the egg until when the embryo reaches its greatest length the head and tail are close together at the anterior pole (Text Fig. I).

While the embryo increases in length the amnion grows laterally between the yolk and the serosa until the folds from the caudal half of the embryo meet and fuse with those from the anterior half enclosing the embryo everywhere within two membranes (Text Fig. L). The last point of fusion is near the tail where the inner portion of the amnion joining the head and tail remains connected with the outer amniotic envelope by a thin strand of amniotic tissue (Text Fig. M). The amnion and serosa remain intact until the larva cuts through them in the process of hatching.

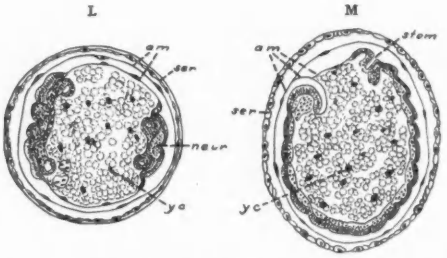

Fig. L. The outer and inner layers of the amnion complete. M. Embryo at its greatest length just before completion of segmentation.

SEGMENTATION

After blastokinesis, when the tail has reached the surface and the embryo has straightened out, segmentation begins. It starts first at the anterior end and becomes evident in a whole mount when the embryo reaches its greatest length (Text Fig. K). As segmentation progresses toward the tail, the embryo shortens until the tail again lies at the posterior pole of the egg (Plate II, 13). Experimental embryologists have found that a morphological differentiation center located in the thoracic region exists in some insect eggs. Schnetter (1934) has found that in the honey bee segmentation starts first in the thoracic region and progresses anteriorly and posteriorly, the abdomen being the last to show any segmentation. The appearance of metameric differentiation and the growth of appendages in Brachyrhinus as indicated in a study of serial sections of timed material indicates that development in this respect is similar to that in the honey bee.

THE SUB-SEROSA

About the time the embryo has formed just under the serosa a substance appears that gradually thickens and hardens until it forms a brown leathery shell around the contents of the egg. Because of its position during the greater part of its existence, I have called it the sub-serosa. It is non-cellular, non-granular, stains a light brown when haemotoxylin and orange G are used and a deep blue with Mallory's connective tissue stain. Unfortunately the presence of the sub-serosa was not noticed until too late during the summer of 1934 to obtain sufficient material to have a chemical analysis of the substance made.

When it first appears as a definite layer next to the serosa at approximately forty hours it is not very thick but lies on the inner surface of the serosa cells and extends down between the cell walls. The serosa cells are still columnar in form as this is the last part of the blastoderm to differentiate (Plate II, 9). However, some changes are evident. The inner walls are no longer even and flat as they were only a few hours previously. Large vacuoles appear in the cytoplasm of the cells and at several points the inner cell walls are interrupted so that the cell contents are continuous with the sub-serosa. This probably indicates that the cells are secreting the material for the new layer.

Occasionally small amounts of sub-serosa can be observed between the early blastoderm cells but not until the embryo is formed does the sub-serosa become extensive. During the earliest stage of ventral plate formation it also appears to be secreted by the amnion cells and probably by the cells of the forming embryo. Large masses appear in the amniotic cavity, and in the yolk (Plate II, 10, 11, 12). In figure 12 it will be noticed that the amnion cells where they are in contact with the sub-serosa have the same appearance as the serosa cells while they are still columnar in that portion of the amnion invaginated into the yolk. By the time the amnion has reached its greatest extent, it has become a thin membrane lying against the inner wall of the sub-serosa, and if it were not for an occasional nucleus one could not detect its presence. Until we know more about the chemical nature of the sub-serosa nothing definite can be said of its function. However, it has been noticed that insect eggs subjected to heat and dry conditions usually have both embryonic membranes well developed, and in addition a heavy chorion is also present in many forms. In Brachyrhinus, the chorion is very thin and affords little protection to the egg. It therefore seems reasonable to assume that the function of the sub-serosa is one of protection.

From a study of the material for the later stages of embryological development it is evident that Brachyrhinus follows very closely the development of other members of the Coleoptera. However, since the material was insufficient to work out in detail the later stages, it seemed inadvisable to include them in this paper. Later when more material is available this study will be completed.

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EXPLANATION OF PLATES

Plate I

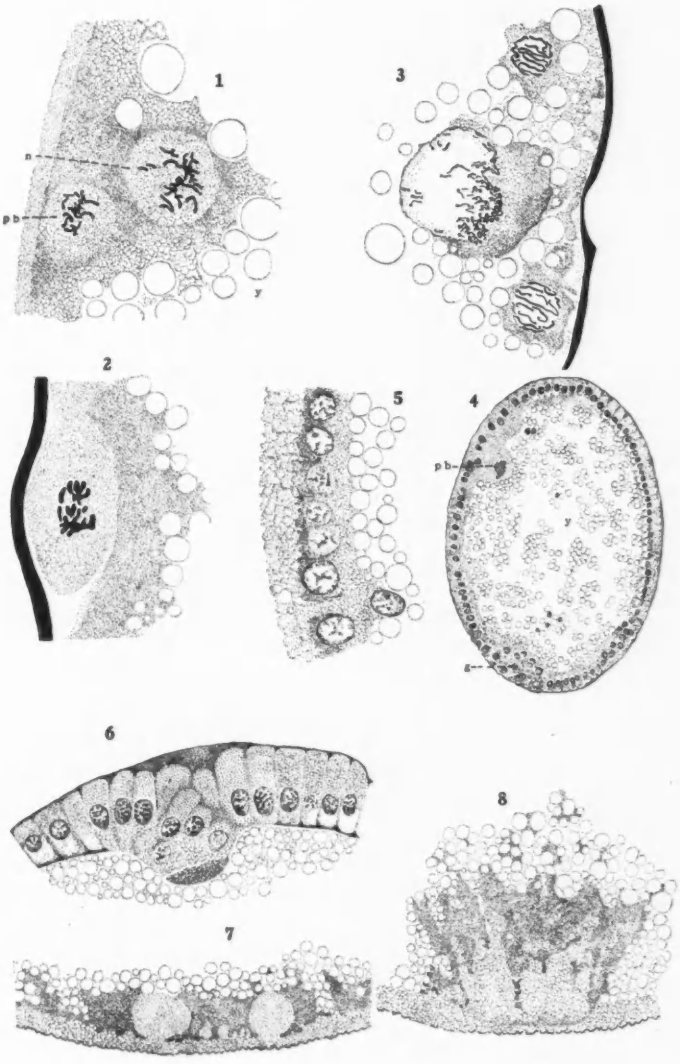
Fig. 1. Nucleus and polar body fifteen minutes after egg was laid just after first maturation division. ×1800.
Fig. 2. Polar body being eliminated from egg. ×2500.
Fig. 3. Polar body disintegrating in yolk with two cleavage nuclei in periphery. ×880.
Fig. 4. Longitudinal section showing polar body disintegrating in yolk and germ cells at posterior end. ×185.
Fig. 5. Longitudinal section of a portion of the blastoderm wall before cell walls have formed showing a cell migrating back to the yolk. ×900.
Fig. 6. Cross section showing primary dorsal organ. ×640.
Fig. 7. Longitudinal section through saucer-shaped germinal cytoplasm. ×620.
Fig. 8. Longitudinal section through germinal cytoplasm forming a mass projecting into yolk. ×600.

Plate II

Fig. 9. Portion of serosa at an early stage in its development showing sub-serosa. ×800.
Fig. 10. Cross section through posterior region of embryo before the tail has invaginated into the yolk showing the deep gastrula groove filled with sub-serosa. ×440.
Fig. 11. Cross section through middle of same embryo. ×450.
Fig. 12. Longitudinal section showing tail invaginated in yolk with head at posterior pole. Sub-serosa appears in the yolk and the amniotic cavity. ×200.
Fig. 13. Longitudinal section of a later stage showing sub-serosa between the amnion and serosa only. ×200.

ABBREVIATIONS

Am.—amnion.
ect.—ectoderm.
cl. n.—cleavage nuclei.
g.—germ cells.
g. c.—germinal cytoplasm.
l. l.—lower layer.
n.—nucleus.
neur.—nerve cord.
p. b.—polar body.
ser.—serosa.
stom.—stomodaeum.
sub-ser.—sub-serosa.
y.—yolk.
y. c.—yolk cells.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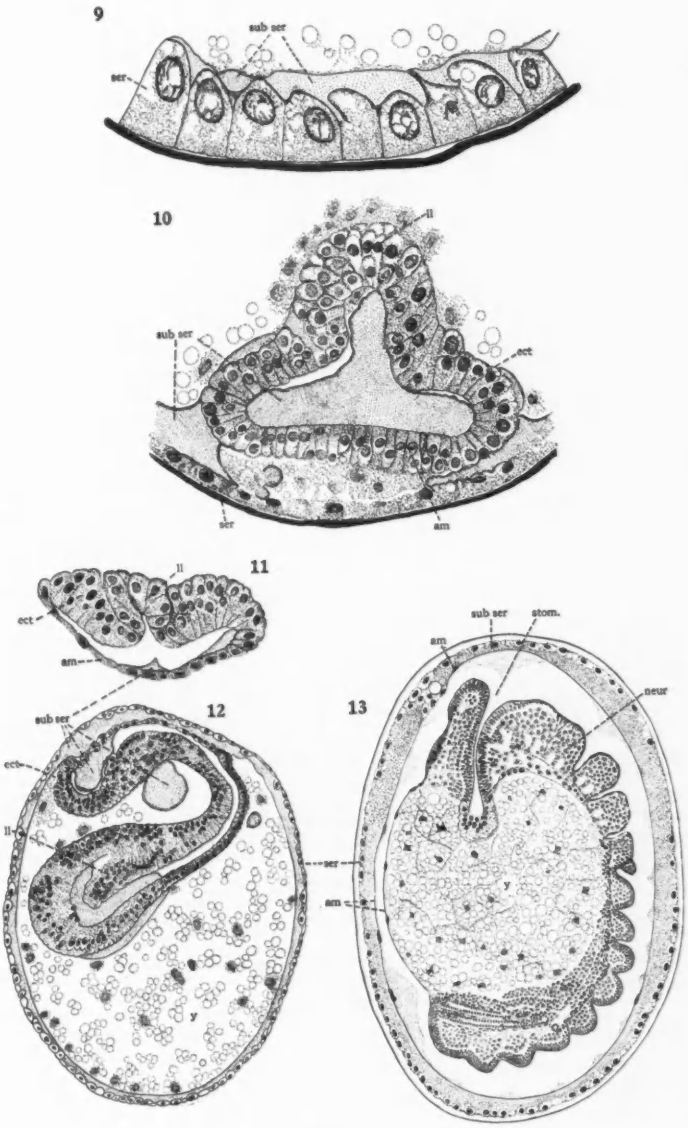
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ALIMENTARY CANAL AND MALPIGHIAN TUBULES OF CERATOMEGILLA FUSCILABRIS (MULS.)

(Coccinellidae, Coleoptera)

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The spotted lady beetle, *Ceratomegilla fuscilabris* (Muls.) (erroneously *Megilla maculata* Deg., a subtropical species), is abundant throughout temperate United States. The adults are gregarious at the time of hibernation and may be found during the winter in clusters under bark of trees or beneath fallen leaves on well-drained slopes.

The larvae feed on insect eggs, aphids and other soft-bodied insects. The adults feed also on pollen and fungi. Examination of the stomach contents of adults revealed, in a few cases, much of the food taken to be conidiospores of *Alternaria* sp., one of the Ascomycetes.

METHODS

Adult beetles collected from foliage or taken from hibernation were killed, fixed in Kahle's fixative, and preserved in 70 percent alcohol. The methods followed in gross dissection and microscopical technique were similar to those used by Jahn (1)[1] except that for some structures a double stain consisting of Fast Green and eosin was preferable to Delafield's haematoxylin and eosin.

GROSS ANATOMY OF THE ALIMENTARY CANAL

Except for a short loop occurring in the ileum, the digestive tract is a straight tube extending dorsally along the long axis of the beetle (Fig. 1). The pharynx and rectum are supported by suspensory muscles, and the remaining organs float in the body fluids although supported somewhat by tracheae and fatty tissue.

The fore-intestine: The labrum, the mandibles, and the hypopharynx are enclosed by an extra-oral mouth cavity. The flat, triangular pharynx narrows posteriorly and joins the oesophagus posterodorsally. The narrow oesophagus lies entirely within the head capsule. Within this transparent organ several longitudinal folds can be seen in gross dissection. In some individuals a pair of pouches appears at the junction of the oesophagus and proventriculus. The proventriculus is a pear-shaped bulb, twice the diameter of the oesophagus, lying in the anterior part of the prothorax. It is attached to the stomach,

[1]Numbers in parenthesis refer to Literature Cited, pp. 19–20.

or mid-intestine, posteroventrally and is partly obscured laterally by the paired caeca of the mid-intestine (Figs. 1, 2, and 3). There are no salivary glands.

The mid-intestine: The stomach is a straight tube extending from the middle of the prothorax to the fifth abdominal segment, where it narrows to half its former width (Fig. 1). Anteriorly, where the greatest width of the digestive system occurs, a pair of gastric caeca appears. These caeca are covered with minute papillae containing the nidi, or cell nests, of the enteric epithelium.

The hind-intestine: The ileum, which is much narrower than the stomach, turns to one side of the midline of the body cavity and forms a complete loop. Like the oesophagus, the ileum is semitransparent, and several internal longitudinal folds are visible from without. The colon is slightly wider than the ileum and increases to its greatest width posteriorly at the junction with the rectum. The rectum is narrower than the colon and is twice as long as wide.

HISTOLOGY OF THE ALIMENTARY CANAL

FORE-INTESTINE

The stomodaeal pharynx and oesophagus (Figs. 2 and 4): The primary intima is heavy throughout the fore-intestine. In the pharynx the intima is smooth but becomes undulated and deeply pitted in the oesophagus. Each pit contains a thick, short spine (Fig. 4, *SP*) which projects posteriorly into the lumen. Farther posteriorly the pits and spines are replaced by posteriorly directed overlapping scales, each of which contains five or six minute striae. The secondary intima (*S INT*) has no definite shape and varies throughout the fore-intestine both in thickness and in amount of granular material. The cells of the epithelium (*EP*) are indistinct but appear to be elongate.

Two to three sets of longitudinal muscles (*LON MUS*) are found outside the pharyngeal epithelium. Occasionally epithelial cells are pushed aside by suspensory muscles having their insertion on the intima (*INT*). One or two sets of circular muscles (*CIR MUS*) persist throughout the length of the fore-intestine.

The proventriculus (Figs. 2 and 3): The intima supports 12 or more rows of spines, each having 15 to 25 posteriorly directed spines (*SP*) which project into the lumen.

The epithelium is prominent in the fore part of the proventriculus but diminishes gradually posteriorly, where flattened nuclei alone are distinguishable.

The longitudinal muscles of the proventriculus are heavy, especially in the posterior part, where many of them are inserted on the intima (Fig. 2). The circular muscles are heaviest at each end of the organ. Just posterior to the oesophageal valve and throughout the length of the mid-intestine, the external layer of longitudinal muscles is found outside of the circular muscles.

The oesophageal valve (Fig. 2, *OES VALVE*): The posterior end of the proventriculus projects into the mid-intestine, where it becomes constricted to form the oesophageal valve.

The primary cuticula within the valve is smooth but becomes slightly undulated as it turns into the mid-intestine.

The epithelium is similar to that of the proventriculus, but on the outer side of the valve facing the lumen of the mid-intestine the cells become three times as long as wide for a distance of 30 cells.

The heavy circular muscles of the posterior part of the proventriculus regulate the opening and closing of the valve.

MID-INTESTINE

The peritrophic membrane (*PER M*) of the mid-intestine or stomach (Figs. 3, 5, and 6), a non-cellular grayish membrane, may be secreted by the well-defined press. Food passing the oesophageal valve into the stomach is enclosed by the peritrophic membrane, which may serve as protection to the enteric epithelium. Between the peritrophic membrane and the enteric epithelium (*E EP*) are bits of cells sloughed from the epithelium.

The enteric epithelium functions in a holocrine manner. After food passes into the stomach, the cells rupture and the remaining cell fragments slough as new cells push out from the cell nests. Individuals not having fed for some time have long epithelial cells. During hibernation these cells grow until they nearly close the lumen, but as dormancy is broken the old cells are voided. Enteric epithelial cells are formed first in nidi (Figs. 3, 5, and 6, *NID*). The nidi are embedded in a screen-like matrix of circular and longitudinal muscles (Fig. 5). Seventeen embryonic cells were counted in one nest. In beetles that have not fed for some time the ends of the epithelial cells bordering the lumen bear a striated border, generally known as the "rhabdorium."

The basement membrane (*B MEM*) is more clearly defined in the mid-intestine than elsewhere in the digestive tract. It appears as a thin layer of indistinct cells bordering the epithelium and is perforated at intervals by cell nests.

One to three sets of circular muscles are found separating the cell nests. The longitudinal muscles are few and inconspicuous and show best in cross section.

HIND-INTESTINE

The pyloric valve (Fig. 11): The pyloric valve is not so distinct in *C. fuscilabris* as in the phytophagous coccinellids. The valve occurs at the juncture of the ileum and the mid-intestine and slightly below the origin of the Malpighian tubules (*MAL T*). It is supported by three sets of circular muscles which pinch the epithelial folds of the ileum. These folds are continuous with the insertions of the Malpighian tubules.

The epithelial cells are long and narrow, in contrast with the flat cells of the ileum.

The ileum (Fig. 13): The intima is thin and convoluted and possesses overlapping scales bearing posteriorly directed striae.

The longitudinal muscles of the mid-intestine divide, on reaching the ileum, part continuing posteriorly outside the circular muscles and the remainder passing between the circular muscles and the epithelium. Circular muscles cover the ileum throughout its length.

The colon (Fig. 12): The intima is slightly heavier in the colon than in the ileum and faces the six folds of large epithelial cells.

The musculature is similar to that found in the ileum.

The rectum (Fig. 7): The intima is thinner than that of the colon and possesses long spines near the anal opening.

The epithelial cells are small and appear in eight to ten longitudinal folds.

Suspensory muscles are attached to the intima at several points on the rectum.

THE MALPIGHIAN TUBULES

The Malpighian tubules of insects arise as evaginations of the ileum near the junction of the mid- and hind-intestines. Their evagination, loci, number, length, and course throughout the body cavity often differ between taxonomically related species having dissimilar food habits and waste products.

In *C. fuscilabris* the Malpighian tubules are six in number and arise in the same plane equidistant from each other and at the anterior end of the ileum. For convenience in discussion the tubule may be divided into two parts: (*a*) a free, beaded undulated portion extending from the evagination on the alimentary canal forward through the body cavity to the anterior limits of the stomach, then back into the posterior part of the abdomen, and finally returning to the proximity of the alimentary canal near the junction of the ileum and the colon; and (*b*) and enclosed, or reassociated portion, lying between the layers of the peritoneum encasing the colon.

The fact that the tubules return to the hind-intestine suggests that there may be a second or posterior termination through which wastes are voided. Woods (2), quoting Ramdohr, lists 22 genera of Coleoptera, representing 10 families, in which the Malpighian tubules become reassociated with the alimentary canal at their distal ends. Ishimori (3) has figured the terminalia of the tubules in a great many lepidopterous larvae in which the same condition exists.

The writer believes that there is an indirect passage in *C. fuscilabris* and other Coleoptera possessing the reassociated condition of the Malpighian tubules, by means of which liquid wastes are passed into the hind-intestine.

In *C. fuscilabris* the reassociated portions of the tubules are gathered from the body cavity by an inverted funnel-shaped matrix or envelope of peritoneal tissues (Figs. 12, 13, 14, 15, and 16, *PERI*). The enclosed tubules follow the contour of the colon posteriorly and spread in a definite and apparently specific pattern around the colon (Fig. 16). The envelope holds the tubules loosely at the anterior end of the colon but narrows posteriorly, forcing the tubules between the intestinal musculature until the junction of the colon and the rectum is reached, where the peritoneum cuts through the layers of intestinal tissues obliquely and is inserted on a narrow ring of non-staining primary intima peculiar to this region. The peritoneal envelope consists of an outer heavy layer bathed by fluids of the body cavity and one to eight or more inner layers (varying with the species) (Figs. 13,

14, and 15), which follow loosely the general contour of the outer heavy layer and the reassociated parts of the Malpighian tubules. In gross dissection this envelope may be removed intact from around the alimentary canal (Fig. 16).

The Malpighian tubules are attached at many places to the heavy outer layer of peritoneum, causing the tubules to appear ovoid in cross section. At these points of attachment ducts (Fig. 15, *DUCT*) open up in the wall of the tubule through which a part of the contents of the collapsed cells of the tubule stream out into the matrix of the peritoneal tissues. However, the cell nuclei lodge in the mouths of the ducts and are retained within the tubules.

After entering the peritoneal matrix, the liquid wastes appear to be transported posteriorly to the insertion of the peritoneum on the intima of the intestine. The large, flat epithelial cells characteristic of the hind-intestine do not appear between the insertions of each peritoneal layer on the intima, but are replaced by spindle-shaped cells having prominent nuclei.

As previously stated, the insertions of the peritoneal envelope at the junction of the colon and the rectum occur on a narrow ring of non-staining sclerotic intima (Figs. 13, 14, and 15). Sections of this brittle sclerotic material examined under oil immersion reveal a maximum of six rows of minute openings leading from the peritoneal matrix through the region of the intima and opening in the lumen of the intestine.

Tracing liquid wastes from the reassociated portion of the Malpighian tubule to the hind-intestine (Fig. 15), we find that certain cells of the tubule secrete their contents into the lumen of the tubule and pass through ducts in the walls of the tubule into the matrix of the peritoneal envelope, where they are transported posteriorly to the insertion of the layers of the peritoneum and pass through minute openings in the non-staining ring of intima into the lumen of the hind-intestine.

Sections made through the colon and the rectum of adults of *Chelymorpha cassidea* Fab., *Diabrotica vittata* Fab., *Epilachna corrupta* Muls., *Epilachna mexicana* Guer., *Penthe pimelia* Fab., *Bolitotherus cornutus* Panz., and *Tribolium confusum* Jacq.-Duv., reveal essentially the same relationship between the Malpighian tubules and secondary terminalia as in *Ceratomegilla fuscilabris*. These conditions will be presented in another paper.

The work of Poll (1934), on certain Buprestids, presents an interesting variation of the conditions reported by the present writer. Poll was unable to trace a luminal connection between the reassociated ends of the Malpighian tubules and the hind intestine. Instead, he found at the junction of the colon and rectum a series of small supplemental tubules having sclerotized luminal connections with the intestine. These he describes as true intestinal caecae.

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EXPLANATION OF PLATES

Plate I

Fig. 1. Gross dissection of adult of *Ceratomegilla fuscilabris* (Muls.), showing organs of the alimentary canal and the Malpighian tubules.
Fig. 2. Camera lucida drawing of longitudinal section through the oesophagus, proventriculus, and oesophageal valve.

Plate II

Fig. 3. Camera lucida drawing of cross section through proventriculus and paired caeca of mid-intestine.
Fig. 4. Longitudinal section through the fore-intestine, showing undulating intima and spines.
Fig. 5. Camera lucida drawing of longitudinal section through the enteric epithelium of the mid-intestine (from hibernating adult).
Fig. 6. Camera lucida drawing of cross section through the mid-intestine.

Plate III

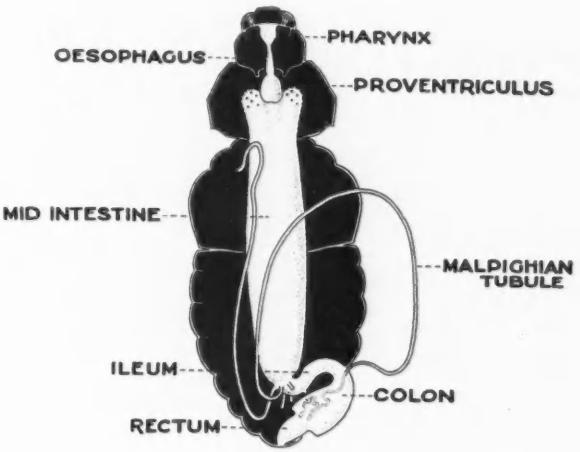
Fig. 7. Camera lucida drawing of cross section through rectum.
Fig. 8. Cross section of Malpighian tubule in wall of colon.
Fig. 9. Longitudinal section through wall of rectum.
Fig. 10. Cross section of Malpighian tubule.
Fig. 11. Camera lucida drawing of cross section through the pyloric valve near insertion of the Malpighian tubules.
Fig. 12. Camera lucida drawing of cross section of colon, showing peritoneal matrix and enclosed Malpighian tubules.

Plate IV

Fig. 13. Camera lucida drawing of longitudinal section through the junction of colon and rectum, showing insertion of peritoneal matrix on intima (*Epilachna mexicana* Guer.).
Fig. 14. Camera lucida drawing of longitudinal section through junction of colon and rectum, showing insertion of peritoneal matrix on intima (*Ceratomegilla fuscilabris* Muls.).
Fig. 15. Diagrammatic drawing showing how liquid wastes (illustrated by stippling) leave the Malpighian tubule and enter the hind-intestine.
Fig. 16. Specific ramification of the reassociated portion of the Malpighian tubule in the peritoneal matrix.

ABBREVIATIONS USED ON PLATES

B MEM—basement membrane.
CIR MUS—circular muscles.
E EP—enteric epithelium.
EP—epithelium.
INT—intima.
LON MUS—longitudinal muscles.
LUM—lumen.
MAL T—Malpighian tubule.
NID—nidus.
OES—oesophagus.
OES VALVE—oesophageal valve.
PERI—peritoneum.
PER M—peritrophic membrane.
SB—striated border.
S INT—secondary intima.
SP—spine.
TRA—trachea.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MID INTESTINE
MALPIGHIAN TUBULE
ILEUM
COLON
RECTUM

FIG. 1.

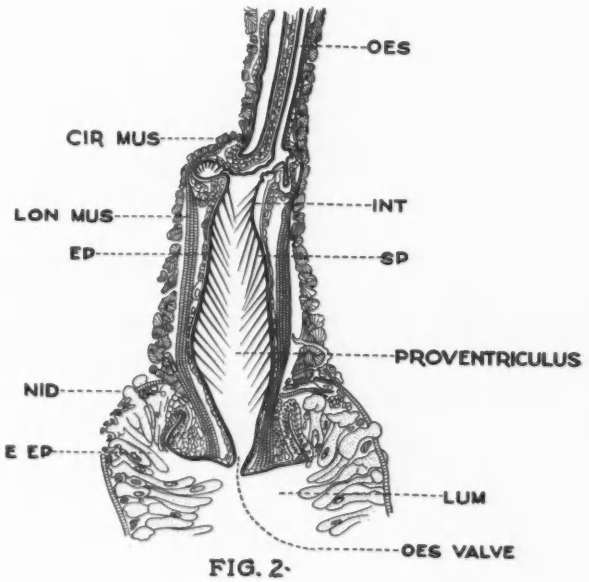
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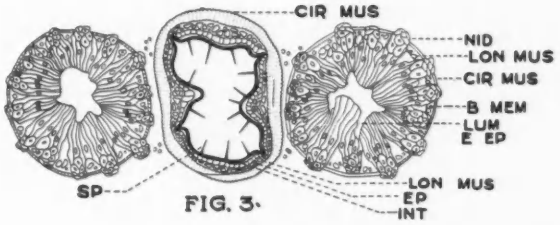
FIG. 2.



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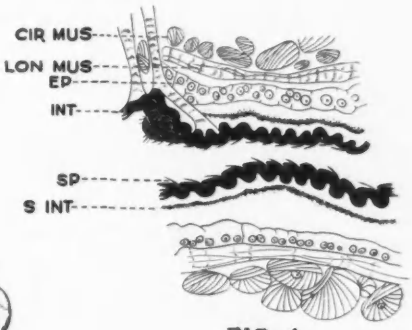

FIG. 4.

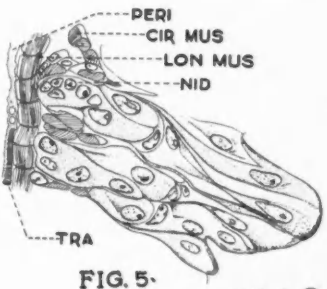

FIG. 5.

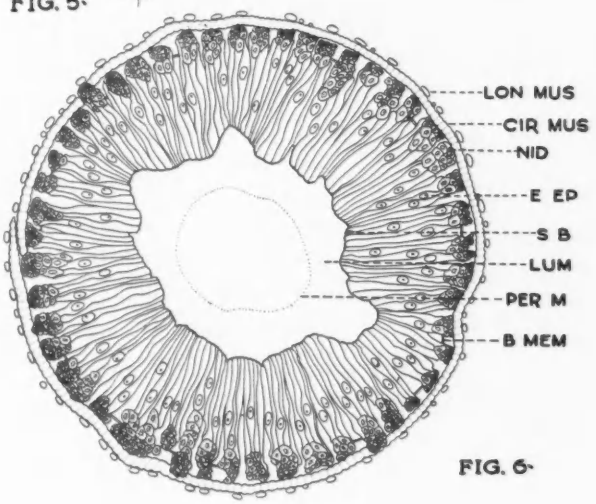

FIG. 6.

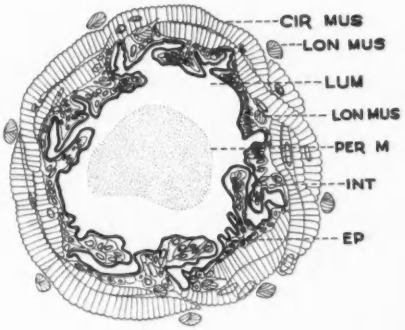

FIG. 7.

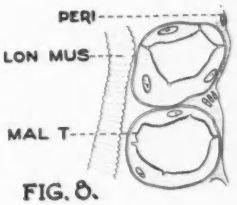

FIG. 8.

FIG. 9.

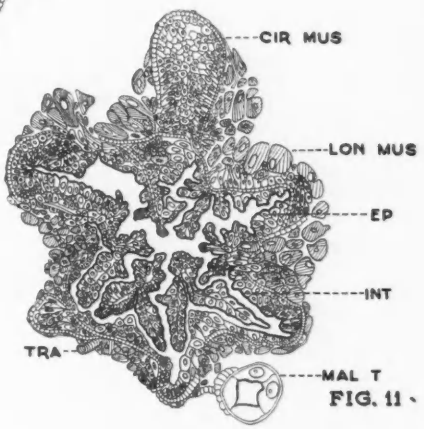

FIG. 11.

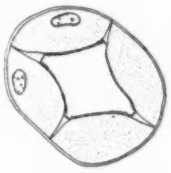

FIG. 10.

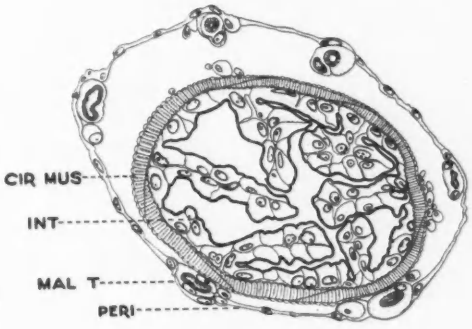

FIG. 12.

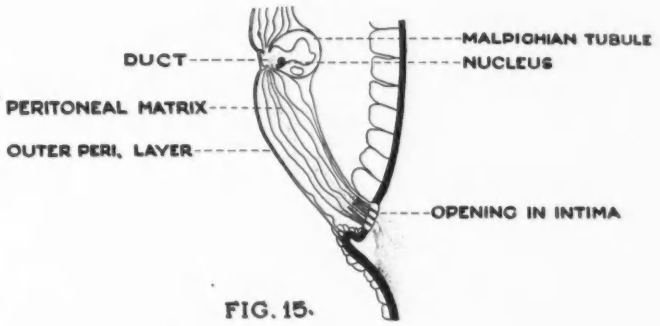

FIG. 15.

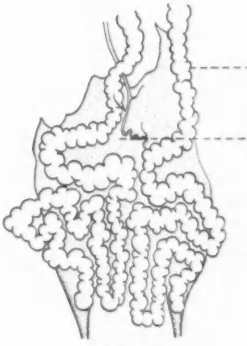

FIG. 16.

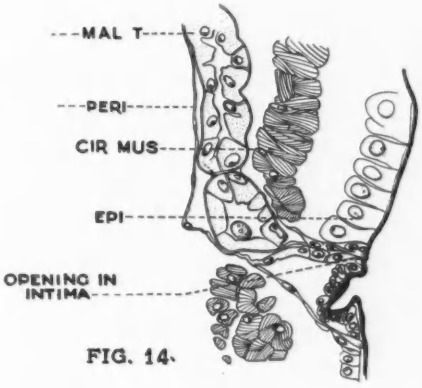

FIG. 14.

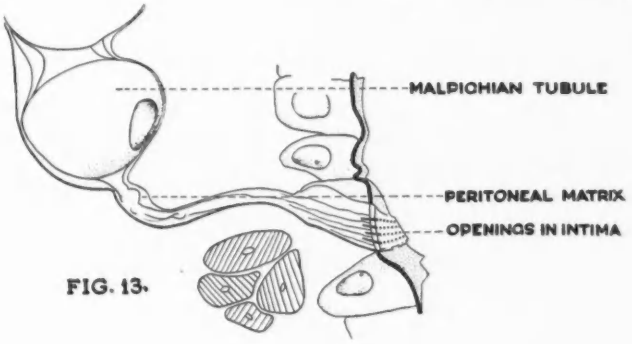

FIG. 13.

NEW SPECIES AND RECORDS OF NEARCTIC MUTILLID WASPS OF THE GENUS DASYMUTILLA[1]

(Hymenoptera)

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University of Minnesota, Saint Paul, Minnesota

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Stevensi 44
Thetis 42
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The following descriptions of new species, records and notes have been added to our knowledge of the Mutillid genus *Dasymutilla* since my revision of that genus in 1928, Bulletin 143 United States National Museum, pp. 1-351, text figs. 1-28, Pls. 1-5. A revised key to the species is also included.

KEY TO THE SPECIES

FEMALES

1. Apices of middle and hind femora squarely truncate, the surface of the outer lobe of the truncation sulcate 92
   Apices of middle and hind femora more or less rounded, not modified as above 2
2. Dorsum of thorax longer than broad by actual measurement, usually very distinctly longer than broad 20
   Dorsum of thorax as broad, sometimes slightly broader than it is long, by actual measurement 3
3. Entire body and legs clothed with ivory-white pubescence. (Page 42) **thetis**
   Pubescence of body and legs colored otherwise 4
4. Second abdominal sternite scabrous at the sides and apex 5
   Second abdominal sternite not at all scabrous; punctate 7
5. Pubescence of abdominal tergites two to five concolorous 6
   Apical fringe of tergite two, and pubescence of tergite three entirely black, **furina**

[1]Paper No. 1151 of the Scientific Journal Series of the Minnesota Agricultural Experiment Station.

6. Metapleurae, propodeum, first abdominal tergite, and anterior margin of second tergite sparsely clothed with black hairs. (Page 42)..... **eminentia**
Entire insect clothed with pale pubescence, except anterior median spot of second tergite, black..... **scabra**
7. Head distinctly broader than the thorax..... 8
Head narrower than the thorax..... 9
8. Carina of first sternite produced anteriorly into a blunt tooth; area of golden yellow pubescence on abdomen above with an anterior median emargination..... **aureola**
Carina of first sternite prominent but not produced into a tooth anteriorly; area of scarlet pubescence on abdomen above without an anterior median emargination..... **aureola** var. **pacifica**
9. Antennal scrobes carinate above..... 10
Antennal scrobes not carinate above..... 13
10. Thorax with a distinct scutellar scale; pygidium longitudinally rugose; vestiture white and black..... **nocturna**
Thorax without a scutellar scale; pygidium irregularly rugose; no white pubescence in the vestiture..... 11
11. Head and thorax entirely black..... **zelaya**
Pubescence of head and thorax ferruginous..... 12
12. Pubescence of tergites three to five black, at least laterally..... **homole**
Pubescence of tergites three to five entirely bright red to yellow..**fulvohirta**
13. Mandibles bidentate, that is, acute at the apex, unidentate on the inner margin..... 17
Mandibles tridentate, that is, acute at the apex, bidentate subapically on the inner margin..... 14
14. Head and thorax black. (Page 39.)..... **waco**
Head and thorax ferruginous..... 15
15. Pubescence of abdomen beneath black..... 16
Pubescence of abdomen beneath pale..... **harmonia**
16. Apical fringe of second tergite entirely black, pubescence of tergites three to five entirely black. (Page 40)..... **nigricauda**
Apical fringe of second tergite pale medially and laterally, tergite three mostly pale, tergites four and five pale, except for erect, dark hairs **montivagoides**
17. Body sparsely pubescent; pygidium longitudinally striate. (Page 40) . **dawsoni**
Body thickly pubescent; pygidium irregularly to longitudinally rugose.... 18
18. Pubescence of dorsums of thorax and abdomen concolorous..... 19
Pubescence of dorsum of thorax whitish, with scattered, erect, black hairs; a triangular black spot of black pubescence anteriorly and posteriorly, the latter not as conspicuous as the former; pubescence of second tergite scarlet. (Page 43)..... **dugesii**
19. Pubescence of body above, principally scarlet..... **foxi**
Pubescence of body above whitish, slightly tinged with yellow..... **phoenix**
20. Entire insect clothed with long, coarse, white hairs..... 21
Pubescence of body and legs colored otherwise..... 22
21. Pygidium irregularly rugose; color of body and legs red; genae rounded posteriorly..... **gloriosa**
Pygidium prominently longitudinally striate; color of body and legs blackish; genae bounded posteriorly by an obscure carina... **pseudopappus**
22. Pygidium pubescent..... **bollii**
Pygidium not pubescent..... 23
23. Scutellar scale evident, usually prominent..... 30
Scutellar scale entirely absent..... 24
24. Genae not as coarsely punctured as the front and vertex, rounded at the posterior margin..... 25
Genae very coarsely punctured like the front and vertex, the posterior margins defined by a distinct carina; pubescence brilliant crimson. (Page 42)..... **fulgida**
25. Pubescence of abdominal tergites two to five concolorous, rather dense and erect..... 26
Pubescence of abdominal tergites two to five not concolorous, sparse.... 27

26. Pubescence of head and thorax black, that of the abdomen fulvous...**nupera**
Pubescence of front, vertex, thorax above, and abdomen above concolorous, ochraceous. (Page 44).....**stevensi**
27. Second abdominal tergite with very large, separated, foveate punctures, each bearing an erect hair; no other pubescence on disk of second tergite. (Page 44).....**dionysia**
Second abdominal tergite with close, large elongate punctures; the pubescence of the second tergite mostly recumbent..... 28
28. Apical fringes of first and second abdominal tergites entirely pale..**texanella**
Apical fringes of first and second abdominal tergites in part pale..... 29
29. Only lateral extremes of apical fringe of second tergite pale and glittering; remainder of apical fringe black. (Page 43).....**nigripes**
Lateral extremes and median spot of apical fringe of second abdominal tergite pale and glittering, the interspaces black. (Page 44), **nigripes** var. **sparsa**
30. Postero-lateral angles of the head prominent; conspicuously carinate or tuberculate..... 31
Postero-lateral angles of the head not prominent; not conspicuously carinate or tuberculate..... 51
31. Head, thorax, and abdomen clothed above with long, dense, erect pubescence..... 32
Head, thorax, and abdomen above with sparse, appressed pubescence.... 33
32. Pubescence of second tergite, except anterior fourth, and third tergite entirely, yellow.....**californica**
Apical margin of second tergite medially, and third tergite medially, with black pubescence. (Page 51).....**californica** var. **clio**
33. Antennal scrobes bounded caudally by a delicate carina.....**cariniceps**
Antennal scrobes not bounded caudally by a carina..... 34
34. Postero-lateral angles of the head bearing an oblique, elongate, subparallel-sided, glabrous tubercle directed outward toward the eyes.... 35
Postero-lateral angles of the head bearing a more or less prominent glabrous tubercle, but either broadly triangular or subreniform in outline..... 46
35. Thorax black.....**wileyae**
Thorax ferruginous..... 36
36. Head black, clothed more or less with ferruginous pubescence..... 37
Head entirely ferruginous..... 39
37. Abdomen entirely black.....**electra**
Second abdominal tergite with a pair of pale yellow spots on the apical half. 38
38. Yellow spots on second tergite large and conspicuous; tergites four and five clothed with pale, glittering pubescence.....**nitidula**
Yellow spots on second tergite small, sometimes almost obsolete; tergites three to five clothed entirely with black pubescence. (Page 47), **nitidula** var. **nigridia**
39. Abdomen largely black, the second tergite maculated with two or four pale yellow spots..... 40
Abdomen largely ferruginous, the second tergite more or less conspicuously maculated with four pale ferruginous spots..... 43
40. Second tergite with only two pale spots..... 41
Second tergite with four pale spots..... 42
41. Dorsal part of posterior face of propodeum with a thick brush of long, coarse hairs; distance between the tubercles on posterior margin of head much greater than the least distance between the inner margin of the eyes. (Page 46).....**curticeps**
Propodeum without any such brush of hairs; distance between the tubercles on posterior margin of the head equal to the least distance between the inner margins of the eyes. (Page 46).....**biguttata**
42. Apical fringes of first second, and third abdominal tergites black, **atrifimbriata**
Apical fringes of all the abdominal tergites pale.....**quadriguttata**
43. Apical fringes of first, second, and third tergites black; subapical margin of second tergite, and third tergite entirely (except narrow lateral margins of each), clothed with black pubescence. (Page 46).....**alesia**

Apical fringes of all the tergites mostly pale; occasionally the apical fringe of the first tergite black, or apical fringes of second and third tergites narrowly interrupted medially..... 44

44. Posterior margin of head slightly concave, somewhat sinuate, the postero-lateral angles very prominent.....**cypris**

Posterior margin of head distinctly convex, the postero-lateral angles somewhat prominent..... 45

45. Striae of pygidium continuing to the apical margin.....**interrupta**

Striae of pygidium terminating considerably before the apical margin, the apical fourth or fifth smooth, unsculptured.....**allardi**

46. Dorsal and posterior face of propodeum strongly asperated.....**chattahoochei**

Dorsal and posterior face of propodeum foveolate or coarsely rugose..... 47

47. Distinctly ferruginous throughout..... 48

Thorax bright ferruginous, the head darker, the abdomen mostly black.. 50

48. Dorsum of propodeum with a thin or thick brush of pubescence; apical fringe of first abdominal tergite pale..... 49

Dorsum of propodeum with only sparse, short pubescence; apical fringe of first abdominal tergite black.....**anguliceps**

49. Dorsum of propodeum with a thick brush of glittering, pale pubescence; apical fringe of second tergite mostly black. (Page 48).....**corcyra**

Dorsum of propodeum with a thin brush of black pubescence; apical fringe of second tergite pale, interrupted medially with black. (Page 48).....**beameri**

50. Second abdominal tergite with a large campanulate yellow spot; apical fringes of first, second and third tergites black. (Page 47)....**campanula**

Second abdominal tergite with a pair of yellowish spots on the posterior half; apical fringes of all the tergites pale. (Page 50).....**parksi**

51. Antennal scrobes strongly carinate above, the carina extending from the antennal tubercles almost to the margins of the eyes..... 76

Antennal scrobes weakly carinate, or not at all carinate above; if weakly carinate, the carina extends a little more than half the distance from the antennal tubercles to the margins of the eyes..... 52

52. Antennal scrobes feebly carinate above, the carina extending a little more than half the distance between the antennal tubercles and the eyes..... 53

Antennal scrobes not at all carinate above..... 56

53. Segments three to ten of the flagellum broadly, deeply, longitudinally sulcate dorsally.....**sulcatulla**

Flagellar segments all normal, not sulcate..... 54

54. Pygidium rugose; dorsal areas of head, thorax, and abdomen clothed with long, dense, erect, scarlet pubescence.....**flammifera**

Pygidium distinctly longitudinally striate; pubescence not scarlet..... 55

55. Pubescence of head and thorax black, not concolorous with that of the abdomen. (Page 46).....**melanippe**

Pubescence of vertex and dorsum of thorax orange rufous, concolorous with that of the abdomen.....**melanippe** var. **conformis**

56. Pygidium irregularly rugose..... 57

Pygidium longitudinally striate..... 58

57. Pubescence of body above white. (Page 45).....**clytemnestra**

Pubescence of body above varying from light yellow to red. (Page 45), **coccineohirta**

58. Head wider than the thorax..... 59

Head sometimes almost as wide, but not wider than the thorax..... 60

59. Head and thorax with black pubescence; abdomen with red pubescence.**gorgon**

Head, thorax and abdomen with yellowish pubescence.....**leda**

60. Pubescence of abdominal tergites two to five concolorous; apical fringes of sternites two to five ferruginous; pubescence of head and thorax black. (Page 54).....**klugioides**

Pubescence of abdominal tergites two to five not concolorous; pubescence of head and thorax colored otherwise..... 61

61. Posterior face of propodeum conspicuously clothed with silvery or very pale golden pubescence..... 71

Posterior face of propodeum either almost bare, or clothed with ferruginous or yellow pubescence..... 62

62. Postero-lateral angles of head angulate; posterior face of propodeum deeply, coarsely foveolate, almost bare..... **rugulosa**
Postero-lateral angles of head rounded, not at all angulate..... 63
63. Abdominal sternites clothed with black pubescence..... 64
Abdominal sternites clothed with pale, glittering pubescence..... 65
64. Disk of second abdominal tergite with large, close, elongate punctures, the latero-anterior areas sparsely punctate and shining; dorsum of thorax and abdomen with sparse, mostly appressed pubescence. **praegrandis**
Disk of second abdominal tergite with moderate, distinct, irregular punctures, the latero-anterior areas densely punctate; dorsum of thorax and abdomen with moderately dense, erect, and appressed pubescence, **creusa**
65. Pubescence of abdominal tergites three to five entirely black, except narrow lateral margins pale..... **creusa** var. **bellona**
Pubescence of abdominal tergites three to five not entirely black; either broad lateral margins of tergites three to five, tergites three to five entirely, or tergites four and five entirely pale..... 66
66. Pubescence of dorsal areas of head, thorax, and abdomen, sparse and appressed; pubescence of apical margin of second abdominal tergite black. 67
Pubescence of dorsal areas of head, thorax, and abdomen long, dense, and erect; pubescence of apical margin of second tergite ferruginous, the apical fringe whitish, interrupted medially with black..... **ursula**
67. Dorsum of thorax with a transverse, sinuate carina immediately anterior to the scutellar scale; carina of first abdominal sternite produced anteriorly into a prominent tooth..... 68
Dorsum of thorax without a transverse, sinuate carina; only scutellar scale present; carina of first sternite usually bidentate..... 69
68. Pubescence of abdominal tergites three to five pale, glittering; apical margin of second tergite black, sometimes interrupted medially by a spot of pale pubescence..... **lepeletierii**
Pubescence of abdominal tergites four and five pale; apical margin of second tergite, and third tergite entirely, black. (Page 45)... **bioculata**
69. Apical fringe of first abdominal tergite pale; that of the second tergite pale, narrowly interrupted medially with black..... 70
Apical fringes of first and second abdominal tergites largely black; broad apical margin of second tergite black..... **vesta**
70. Front deeply, confluently punctate; body moderately pubescent, **vesta** var. **errans**
Front with shallow, separated punctures; body very sparsely pubescent. (Page 44)..... **vesta** var. **sappho**
71. First segment of flagellum about twice as long as it is wide at the apex, almost as long as segments three and four united; second abdominal tergite coarsely, foveately punctate..... 72
First segment of flagellum distinctly shorter than twice its width at the apex, much shorter than segments three and four united; second abdominal tergite moderately punctate..... 74
72. Head and thorax pale pubescent and with scattered, erect, black hairs; no definite areas of black pubescence on vertex, or dorsum of thorax. **eurynome**
Head and thorax more or less pale pubescent, but vertex, or dorsum of thorax with definite areas of black pubescence..... 73
73. Vertex and mesonotal area with the pubescence predominantly black; second abdominal tergite with a small, anterior median spot of black pubescence..... **saetigera**
Only the pronotal area with the pubescence predominantly black; second abdominal tergite with a submedian spot of black pubescence..... **bonita**
74. Head and thorax with pale pubescence throughout..... 75
Pronotal and mesonotal areas clothed with black, recumbent pubescence and scattered, erect, dark hairs..... **birkmani**
75. Posterior half of second abdominal tergite with two large, round, confluent, pale yellow spots; punctures of this latter area large, separated, those of the remainder of the disk moderate and dense; apical fringe of third tergite black, interrupted medially by a spot of pale pubescence, **paenulata**

Posterior half of second tergite somewhat paler than remainder of tergite, but punctuation not different; pubescence of third tergite entirely pale ..... **caneo**

76. Genae as coarsely sculptured as the front and vertex 77
Genae not nearly as coarsely sculptured as the front and vertex 86

77. Posterior margin of genae carinate or subcarinate 78
Posterior margin of genae rounded 85

78. Posterior margin of genae strongly carinate; abdominal sternites with an apical fringe of pale or red hairs 79
Posterior margin of genae only subcarinate; abdominal sternites for the most part fringed with black hairs 82

79. Abdomen above clothed with dense, very long, shaggy pubescence; pubescence of first abdominal tergite black 81
Abdomen above with sparse, short pubescence; second tergite with a pair of anterior lateral spots of white recumbent hairs and a thick apical fringe of white hairs; pubescence of first abdominal tergite white 80

80. Median, anterior half of second tergite with sparse, appressed, glittering scarlet pubescence in addition to the erect, black hairs; pale pubescence of third tergite interrupted medially with black. (Page 57) .... **asteria**
Second tergite without sparse, appressed, scarlet pubescence; third tergite clothed throughout with white pubescence ..... **sicheliana**

81. Pubescence of head, thorax, and legs black, of abdomen red ..... **magnifica**
Pubescence of head, thorax, and portions of the legs whitish, of abdomen pale yellow ..... **magna**

82. Head and thorax with black pubescence 84
Head and thorax with pale fulvous or yellowish pubescence 83

83. Body entirely, and legs except tibiae and tarsi clothed with pale fulvous to fulvous pubescence. (Page 55) ..... **hispidaria**
Pleural areas, abdominal sternites, and legs clothed with black pubescence. (Page 53) ..... **calorata**

84. Abdomen (except first segment) entirely clothed above with erect, red hairs ..... **klugii**
First segment, anterior and posterior margins of second abdominal tergite, third tergite entirely, and anterior margin of fourth tergite medially, all black pubescent; remainder of abdomen red pubescent ..... **clotho**

85. Second abdominal tergite with the punctures small and more or less confluent; dorsum of propodeum with red to yellowish pubescence .. **occidentalis**
Second abdominal tergite with the punctures very large and separated, almost foveate; dorsum of propodeum with black pubescence, **occidentalis** var. **comanche**

86. Pubescence of abdominal tergites three to five concolorous with that of tergite two 87
Pubescence of abdominal tergites three to five not concolorous with that of tergite two 88

87. Sternites two to five with a thick apical fringe of pale pubescence .. **satanas**
Sternites two to five with the apical fringe of pubescence black, at least medially ..... **sackenii**

88. Apical fringes of abdominal sternites pale; abdominal tergites three to five with pale pubescence at least laterally ..... **ursula**
Abdomen beneath entirely black; tergites three to five almost entirely black pubescent 89

89. Pygidium distinctly longitudinally striate; pubescence of thorax and abdomen mostly sparse and recumbent ..... **medea**
Pygidium either irregularly or longitudinally rugose; pubescence of thorax and abdomen mostly dense and erect 90

90. Pygidium irregularly rugose; genae with rather large, confluent punctures; eyes of moderate size, the distance between the eye margins and the postero-lateral angles of the head equal to one-half the greatest diameter of the eyes ..... **scitula**
Pygidium longitudinally rugose; genae with small, well-separated punctures; eyes large, the distance between the eye margins and the postero-lateral angles of the head not greater than one-third the greatest diameter of the eyes 91

91. Tergites three to five clothed with black pubescence..... **arenivaga**
Tergites three to five without black pubescence; pubescence of vertex, dorsum of thorax and abdomen above concolorous. (Page 59), **arenivaga** var. **unicolor**
92. Pygidium granulate; thorax pyriform, scutellar scale absent..... 94
Pygidium longitudinally striate; thorax subhexagonal, scutellar scale present..... 93
93. Pubescence of head, thorax, and abdomen concolorous; legs clothed with white hairs..... **helva**
Pubescence of head and thorax black, of abdomen fulvous; legs clothed with black hairs..... **nogalensis**
94. Postero-lateral angles of head carinate..... 95
Postero-lateral angles of head rounded..... 96
95. Carina of postero-lateral angles somewhat crenulate; apical margin of second abdominal tergite with pale pubescence at the middle.... **dilucida**
Carina of postero-lateral angles not crenulate, straight; apical margin of second abdominal tergite with a broad band of black pubescence. (Page 59)..... **chrysocoma**
96. Antennal scrobes distinctly carinate above..... **heliophila**
Antennal scrobes not carinate above..... 97
97. Pubescence of head and thorax sparse, the sculpturing not concealed.. **obscura**
Pubescence of head and thorax dense, concealing the sculpture.... **poecilonota**

MALES

1. Apices of middle and hind femora squarely truncate, the surface of the truncations sulcate; clypeus very prominently bidentate medially..... 72
Apices of middle and hind femora more or less rounded, not modified as above; clypeus feebly bidentate medially..... 2
2. Posterior trochanters produced at the apex within into a prominent blunt tooth..... 3
Posterior trochanters simple, not produced within..... 5
3. Second abdominal sternite convex, not at all scabrose; pygidial area pubescent throughout. (Page 59)..... **creon**
Second abdominal sternite concave, the sides and apex scabrose; pygidial area bare..... 4
4. Body black. (Page 42)..... **eminentia**
Body ferruginous..... **furina**
5. Ventral surface of posterior tibiae very greatly flattened, distinctly arcuate..... 6
Posterior tibiae cylindrical, ventral surface not flattened..... 8
6. Mesonotum clothed with black pubescence; head, pronotum, scutellum, and metanotum with pale pubescence..... 7
Head, pronotum, mesonotum, scutellum, and metanotum with scarlet pubescence..... **foxi**
7. From Kansas, Texas and Colorado..... **dugesii**
From Arizona..... **phoenix**
8. Eyes and ocelli abnormally large and prominent..... 9
Eyes and ocelli normal..... 10
9. Wings subhyaline; pubescence of abdomen from apical margin of second tergite white..... **subhyalina**
Wings fuliginous; pubescence of abdomen from apical margin of second tergite yellow. (Page 60)..... **megalophthalma**
10. Postero-lateral angles of last abdominal sternite dentiform..... 11
Postero-lateral angles of last abdominal sternite rounded, not at all dentiform..... 13
11. Pubescence of thorax above yellowish or reddish..... **fulvohirta**
Pubescence of thorax entirely black..... 12
12. Second abdominal sternite with a median pit densely filled with hairs, **cotulla**
Second abdominal sternite without a median pit or a row of hairs simulating a carina. (Page 42)..... **vandala**
13. Second abdominal sternite with a median pit densely filled with hairs, or with a median row of short, dense, stiff hairs simulating a carina.... 38

Second abdominal sternite plain, without any such modification; (in **bioculata** there is usually a poorly defined pit, but it is not densely filled with hairs; there is occasionally a rudimentary pit in **ursula**) 14
14. Pubescence of abdominal tergites three to six, mostly black 15
Pubescence of abdominal tergites three to six not mostly black, either red, yellow, or white 21
15. Apical abdominal segments inconspicuously grayish pubescent above 16
Apical abdominal segments entirely black pubescent 17
16. Second abdominal segment entirely ferruginous, second tergite with distinct, separated punctures. (Page 53) ..... **arcana**
Second abdominal segment black beneath, and at the base and apex above; second tergite with dense, contiguous punctures ..... **reclusa**
17. Tegulae punctate throughout; posterior third of mesonotum extended laterally each side into a broad distinct lobe 18
Posterior face of tegulae glabrous, impunctate; mesonotum not extended into lateral lobes posteriorly 19
18. Pubescence of head, thorax and legs, black ..... **vesta**
Pubescence of head, thorax, and legs, silvery gray ..... **columbiana**
19. Pubescence of mesonotum and scutellum ferruginous; usually only apical half of second abdominal tergite ferruginous ..... **bioculata**
Pubescence of thorax entirely black; second abdominal tergite almost entirely ferruginous 20
20. Second abdominal sternite ferruginous ..... **nigripes**
Second abdominal sternite dark mahogany red to black. (Page 44) ... **macra**
21. Body entirely black, inconspicuously clothed with grayish pubescence. **gibbosa**
Body entirely black or not, but conspicuously clothed with white, yellow, or red pubescence 22
22. Posterior half of second abdominal tergite clothed with red or yellowish pubescence 25
Pubescence of second abdominal tergite entirely black except the apical, and sometimes subapical fringe colored otherwise 23
23. Pubescence of head, thorax, and apical segments of abdomen concolorous. 24
Pubescence of head and thorax black, that of the apical segments of the abdomen fulvous. (Page 44) ..... **zelaya**
24. Pubescence of vertex, dorsum of thorax, and apical abdominal tergites ochraceous. (Page 45) ..... **myrice**
Pubescence of vertex, dorsum of thorax and apical abdominal tergites whitish ..... **candida**
25. Pygidium with a distinct apical fringe of short, erect hairs 30
Pygidium bare, without a distinct apical fringe of hairs 26
26. Second sternite with a median area of fine, close punctures, each of the latter bearing a fine hair 27
Second sternite with large punctures only, no such median area 28
27. Pubescence of head and thorax black; that of the abdomen varying from red to yellow ..... **atrifulva**
Pubescence of head and thorax varying from red to yellow, concolorous with that of the abdomen ..... **ocydrome**
28. Ultimate abdominal sternite squarely truncate at the apex, with scattered punctures throughout ..... **testaceiventris**
Ultimate abdominal sternite not truncate at the apex, the latter produced forming a blunt median tooth, which is sometimes slightly emarginate; apical third of ultimate sternite glabrous, impunctate 29
29. Pronotum conspicuously emarginate medially; first segment of flagellum very distinctly shorter than the second ..... **abdita**
Pronotum very weakly emarginate medially; first segment of flagellum subequal to the second, especially when measured ventrally .. **coccineohirta**
30. Integument of second abdominal tergite with a pair of large yellow spots on the posterior half (in some specimens the spots coalesce, the disk of the second tergite then being largely yellow) 31
Integument of second abdominal tergite entirely black 32
31. Pubescence of vertex and dorsum of thorax yellowish ..... **ursula**
Pubescence of vertex and dorsum of thorax black ..... **ursula** var. **chiron**

32. Antennal scrobes not at all carinate above..... 33
Antennal scrobes distinctly carinate above..... 35
33. Tegulae finely, setigerously punctate throughout.....**stevensi**
Tegulae glabrous, impunctate, at least on the posterior half..... 34
34. Pubescence of vertex and dorsum of thorax black.....**perilla**
Pubescence of vertex and dorsum of thorax yellowish...**perilla** var. **gentilicia**
35. Ocelli very large and conspicuous; apical fringes of abdominal sternites entirely black.....**doripa**
Ocelli of normal size; apical fringes of abdominal sternites laterally reddish 36
36. First segment of flagellum subequal in length to the second; anterior margin of pronotum not at all emarginate medially.....**glycera**
First segment of flagellum distinctly shorter than the second; anterior margin of pronotum weakly emarginate medially..... 37
37. Pubescence of mesonotum entirely black. (Page 60).....**phaon**
Pubescence of mesonotum in part or entirely red.....**phaon** var. **fimbrialis**
38. Second abdominal sternite with a median pit, densely filled with hairs... 43
Second abdominal sternite with a median row of short, dense, stiff hairs simulating a carina..... 39
39. Pubescence of abdominal tergites three to six black..... 40
Pubescence of abdominal tergites three to six yellowish to ferruginous.... 42
40. Pubescence of vertex and mesonotum golden yellow.....**asopus**
Pubescence of vertex and mesonotum black..... 41
41. Body entirely ferruginous. (Page 40).....**cassandra**
Head, thorax, and apical abdominal segments black.....**bexar**
42. Body largely ferruginous, the pubescence above mostly golden yellow. (Page 39).....**hector**
Head and thorax entirely black; abdominal tergites from anterior portion of second clothed with ferruginous pubescence. (Page 39).....**waco**
43. Apical abdominal tergites clothed with inconspicuous grayish pubescence; remainder of abdomen black pubescent..... 44
Apical abdominal tergites not clothed with inconspicuous grayish pubescence; remainder of abdomen not black pubescent..... 47
44. Pronotum with somewhat dense, conspicuous grayish pubescence..... 45
Pronotum with sparse, inconspicuous blackish pubescence..... 46
45. Integument of abdomen entirely ferruginous; tegulae more or less punctate throughout; mesonotum with grayish pubescence.....**monticola**
Integument of abdomen not entirely ferruginous, the apical abdominal segments black; tegulae glabrous, impunctate except at anterior and inner lateral margins; pubescence of mesonotum dark, almost black. (Page 53).....**polia**
46. Head and thorax for the most part black pubescent; propodeum extraordinarily deeply, foveately reticulate.....**canella**
Head and thorax more or less grayish pubescent; propodeum shallowly, foveately reticulate.....**macilenta**
47. Last abdominal tergite with a fringe of hairs at the apical margin (the fringe usually complete, but sometimes absent medially)..... 48
Last abdominal tergite without an apical fringe of hairs..... 58
48. Head and thorax above clothed with whitish hairs, the abdomen from apex of tergite two with pale yellowish hairs.....**magna**
Body clothed with red and black, or mostly black pubescence..... 49
49. Abdominal tergites from the apical margin of the second clothed entirely with black pubescence..... 53
Abdominal tergites from the apical margin of the second clothed entirely with red or yellow pubescence (sometimes pubescence of posterior half of second tergite is red or yellow, and in one species the pubescence of the fourth and fifth tergites is sometimes black)..... 50
50. Dorsum of thorax, and usually vertex, clothed with red pubescence; second abdominal tergite with only an apical fringe of red hairs..... 51
Head and thorax clothed entirely with black pubescence; posterior half of second abdominal tergite clothed with red pubescence..... 52
51. Eastern species (Louisiana and eastward).....**occidentalis**
Western species (Texas and westward).....**occidentalis** var. **comanche**

52. Abdominal sternites with a fringe of long, reddish pubescence at the apical margin ..... **magnifica**
Abdominal sternites with only a lateral fringe of long, reddish pubescence at the apical margin ..... **klugii**
53. Pit on second sternite distinctly anterior in position ..... **hora**
Pit on second sternite approximately median in position 54
54. Second sternite and second tergite entirely ferruginous 55
Second sternite entirely, and anterior, posterior and lateral margins of second tergite, all black. (Page 51) ..... **hersilia**
55. Antennal scrobes not, or very obscurely carinate above; lateral lobes of anterior division of scutellum coarsely punctate throughout 56
Antennal scrobes distinctly carinate above; anterior fourth or third of lateral lobes of anterior division of scutellum glabrous, impunctate 57
56. Vertex and dorsum of thorax clothed with black pubescence ..... **lepeletierii**
Vertex and dorsum of thorax clothed with fulvous pubescence ..... **pyrrhus**
57. Dorsum of thorax clothed with black pubescence ..... **praegrandis**
Dorsum of thorax clothed with fulvous pubescence ..... **praegrandis** var. **russata**
58. Pubescence of head, thorax, and legs entirely black 59
Pubescence of head and thorax, at least above, not black, colored otherwise 66
59. Posterior margin of second tergite, and tergites three to five entirely, with yellowish, reddish, or orange pubescence 60
Posterior margin of second tergite, and tergites three to five entirely, with black pubescence 62
60. Integument of posterior half of second abdominal tergite yellowish ..... **serenitas**
Integument of posterior half of second abdominal tergite black 61
61. Pronotum emarginate medially on the cephalic margin; fulvous pubescence covering only the apical margin of second tergite ..... **chisos**
Pronotum not emarginate medially on the cephalic margin; fulvous pubescence covering posterior half of second tergite ..... **mimula**
62. Posterior declivity of tegulae setigerously punctate. (Page 53) ..... **gentilis**
Posterior declivity of tegulae glabrous, impunctate 63
63. Pit on second abdominal sternite distinctly anterior in position. (Page 53) ..... **castor**
Pit on second abdominal sternite distinctly median in position 64
64. Narrow lateral rim of second abdominal tergite microscopically punctate, clothed with very fine, short pubescence; first abdominal segment and second abdominal sternite usually black or blackish 65
Narrow lateral rim of second abdominal tergite impunctate, glabrous, bare; first and second abdominal segments, and sometimes propodeum ferruginous ..... **rubricosa**
65. Occiput with distinct lateral depression, leaving a median area distinctly elevated; anterior margin of pronotum distinctly emarginate medially, the dorsum not broadly rounding medially into the cephalic surface. (Page 53) ..... **meracula**
Occiput without or with only very faint lateral depressions; anterior margin of pronotum not emarginate medially; the dorsum broadly rounding medially into the cephalic surface ..... **permista**
66. Head fully as wide as the thorax 67
Head distinctly narrower than the thorax 68
67. Head, thorax, and abdomen, above clothed with golden yellow pubescence, **aureola**
Head, thorax, and abdomen, above clothed with scarlet pubescence, **aureola** var. **pacifica**
68. Pubescence of legs white or pale, abdominal integument for the most part ferruginous 69
Pubescence of legs entirely black; abdominal integument entirely black ... 70
69. Posterior abdominal segment black ..... **intermixta**
Posterior abdominal segments pale ferruginous ..... **poliothrix**
70. Pubescence of abdominal tergites three to six concolorous with the pubescence of the head and thorax above 71
Pubescence of abdominal tergites three to six entirely black, the vertex, thorax above and disk of abdominal tergite two with yellow pubescence, **scitula**

71. Pubescence of second tergite usually entirely black, sometimes the apical fringe whitish or pale yellow; pubescence very long and shaggy..**sackenii**
Posterior third to half of second tergite with red to yellow pubescence; pubescence long, but not shaggy. (Page 56).....**gloriosa**
72. Calcaria dark; head clothed with black pubescence..... 73
Calcaria whitish; head clothed more or less with pale pubescence..... 74
73. Apical fringes of abdominal segments two to six black.....**obscura**
Apical fringes of abdominal segments pale.....**snoworum**
74. Sides of thorax and propodeum bright ferruginous. (Page 59).....**errabunda**
Thorax and propodeum entirely black or dark mahogany red..... 75
75. Pubescence of abdomen entirely pale. (Page 59).....**sophrona**
Abdomen with more or less black pubescence..... 76
76. Lateral processes of scutellum large, glabrous, impunctate; apical fringes of abdominal tergites two to four pale, of five and six black.....**apicalata**
Lateral processes of scutellum small, for the most part punctate; apical fringes not as above..... 77
77. First segment of flagellum distinctly shorter than the second; pubescence of posterior half, and apical fringe of second tergite black; pubescence of remainder of abdomen mostly pale.....**digressa**
First segment of flagellum subequal in length to the second; pubescence of abdomen almost entirely black.....**curialis**

Dasymutilla hector (Blake)

A male specimen which is placed here differs from the typical specimens in having a head and thorax black but clothed with yellowish ferruginous pubescence, and in having the wings subnormally developed; the latter are approximately half the length of the fully developed wings and have the venation almost complete; the wings are not reduced as much as in the rudimentary winged males of *waco*. This specimen is from Morton county, Kansas, August 4, 1924 (C. O. Bare).

Dasymutilla waco (Blake)

Additional male specimens with rudimentary wings have come to my attention since 1928. There is a single male specimen with rudimentary wings in the Museum Nationale d'Histoire Naturelle, Paris bearing a locality label "Texas." This specimen is practically a duplicate of the one described by Fox (1895). A third male specimen in the United States National Museum has no wings at all on one side; on the other side there is no evidence of a front wing but there is what appears to be a rudimentary hind wing. Tegulae, and scales at the base of the hind wing are well developed on both sides. A fourth male specimen, McLennan county, Texas, July 14, 1933 (H. B. Mills), in the University of Minnesota collection has rudimentary wings like the type.

I have again compared the winged specimens which I placed as *waco* in 1928 with these rudimentary winged specimens and can find no structural differences whatever other than the

difference in the development of the wings. For the present I regard this species as having two types of males, those with well developed wings, and rarer individuals with rudimentary wings.

Dasymutilla nigricauda (Viereck)

The type specimen of this species is largely ferruginous with sparse black pubescence on the vertex and margins of dorsum of thorax; disk of second tergite ferruginous and with ferruginous pubescence; tergites three to six black pubescent above and beneath.

I place here several specimens which vary more or less from the type. One, College Station, Texas, May 29, 1930 (H. J. Reinhard) has the thorax only partly ferruginous, the propodeum suffused ventrally with black, while the dorsum of thorax is clothed entirely with sparse, black pubescence. A second, Harmon county, Oklahoma, May 16, 1931 (R. D. Bird), has the head and thorax entirely black but the pubescence typical. Two females, Texas, have the head and thorax entirely black and clothed entirely with sparse, black pubescence. The latter two are very similar in appearance to the females of *waco* but differ in having the abdominal tergites beyond the second clothed with black pubescence instead of ferruginous pubescence.

Other specimens examined: female, Kiowa county, Kansas, July 4, 1923 (R. H. Beamer); two females, College Station, Texas, May 29, 1930 (H. J. Reinhard).

Dasymutilla cassandra Mickel

Specimens examined: male, Fruitville, Florida, August 11, 1930 (L. D. Tuthill); male, Loughman, Florida, August 5, 1930 (R. H. Beamer).

Dasymutilla dawsoni n. sp.

Female.—Ferruginous, except abdominal segments three to six and posterior legs, black; dorsum of head and thorax, and disk of second abdominal tergite clothed with sparse, recumbent, glittering, ferruginous pubescence; apical fringe of first tergite black except the lateral fourths, pale; apical fringe of second tergite pale, interrupted laterally with black, thus the apical fringe with three pale sectors, a broad median one and two extreme lateral sectors; segments three to six clothed above and beneath with pale, glittering pubescence; dorsum of thorax as broad as long; pygidial area distinctly longitudinally striate. Length, 8 mm.

Head ferruginous, the front and vertex clothed with sparse, recumbent, glittering, ferruginous pubescence as well as scattered, erect, fuscous hairs, the genae with sparse, pale, glittering pubescence; mandibles long and slender, dentate at the tip, and with a very small tooth within remote from the tip; clypeus posteriorly with a transverse, elevated ridge but the latter low, not conspicuous; antennal tubercles distinctly separated; scape clothed with sparse, pale ferruginous pubescence; first segment of flagellum one and one-fourth times the length of the second; antennal scrobes not carinate above; front and vertex with moderate, dense, confluent punctures; genae with moderate, close, somewhat confluent punctures; relative widths of head and thorax, 3.6–4.1.

Thorax entirely ferruginous, the disk of the dorsum clothed with sparse, recumbent, glittering, ferruginous pubescence, the margins of the dorsum clothed with very sparse, erect, black hairs; dorsum of thorax as broad as long, slightly pyriform in outline, narrow at the humeral angles, broadest at the anterior spiracles and gradually narrowed posterior to the latter; relative widths of thorax at humeral angles, anterior spiracles, propodeal spiracles and posterior margin of dorsum, 2.9–4.1–2.8–2.6; humeral angles rounded, not at all angulate; dorsum of thorax with moderate, dense, confluent punctures, slightly larger than on the vertex; an indistinct transverse suture separating the mesonotal and propodeal areas; scutellar scale entirely absent; propleurae not defined by a carina, with moderate, indistinct punctures and sparse, pale pubescence; mesopleurae with moderate punctures interspersed anteriorly with very small punctures, clothed with sparse, pale pubescence; metapleurae glabrous, the dorsal half impunctate, the ventral half with intermixed moderate and small punctures; sides of propodeum with moderate, separated punctures; puncturation of dorsum extending onto dorsal third of posterior face of propodeum, the remainder of the latter with sparse, small and fine punctures.

Abdomen ferruginous, except the segments beyond the second black; first segment diskiform, subsessile, more sessile and disk-like than in *fulvohirta;* first tergite glabrous, with sparse, intermixed small and fine punctures and sparse, erect, pale hairs; apical fringe of first tergite black except the lateral fourths pale; second tergite with moderately large, elongate, dense, confluent punctures, clothed with sparse, recumbent, glittering, ferruginous pubescence and scattered, erect, ferruginous hairs, the pubescence becoming paler laterally; broad apical margin of second tergite black, the apical fringe pale and interrupted laterally with black thus divided into three pale sectors, a median one equal in width to the two lateral ones combined; tergites three to five with small, dense punctures and sparse, recumbent, pale, glittering pubescence; pygidial area well developed, distinctly longitudinally striate; first sternite short, with a median, longitudinal carina, conspicuously elevated anteriorly; anterior third of second sternite depressed, the sternite with moderately large, close, slightly confluent punctures throughout; apical fringes of all the sternites pale; sternites three to five with small, close punctures towards the apical margin.

Anterior legs ferruginous; intermediate legs dark ferruginous; posterior legs blackish; all clothed with sparse, pale pubescence; calcaria dark.

Holotype.—Female, Halsey, Nebraska, September 3, 1924 (R. W. Dawson), in University of Minnesota collection.

This species is placed in the group *fulvohirta* on account of the slender, bidentate mandibles, the thorax as broad as long, and the strongly subsessile first abdominal segment. The dorsum of the thorax is strongly convex and this with the obscure suture separating the mesonotal and propodeal areas gives it a somewhat gibbose appearance. The first abdominal segment has all the appearance of a very thin disk applied to the anterior surface of the second segment. This species differs from others in the *fulvohirta* group by the strongly, longitudinally striated pygidium and the much sparser pubescence. Superficially the species has the appearance of an aberrant specimen of *harmonia* but differs in the mandibles and pygidium, and the median pale spot at the posterior margin of the second tergite is a transverse line rather than a spot as in *harmonia*. The first abdominal segment is slightly more sessile than in *harmonia*. I take pleasure in dedicating this species to my friend Dr. R. W. Dawson who collected the specimen.

Dasymutilla vandala Mickel

A second specimen of this species is in the Kansas Agricultural College collection: male, Glen Springs, Texas, July 15, 1930 (H. M. Smith).

Dasymutilla fulgida Mickel

An additional record is: female, Pinal Mts., Gila county, Arizona, April 4, 1932 (D. K. Duncan).

Dasymutilla thetis (Blake)

Specimens examined: two females, Tonto N. Mon, Arizona, July 26, 1932 (R. H. Painter); female, Sells, Arizona, July 31, 1932 (R. H. Painter).

Dasymutilla eminentia Mickel

A female specimen: Dos Cabezos, Arizona, August 2, 1932 (D. K. Duncan), differs from the type material in having the pubescence ferruginous instead of whitish tinged with yellow. The sculpturing of the body and other morphological characteristics, as well as the color pattern of the pubescence is the same as in the allotype female.

Dasymutilla dugesii (Ckll. and Casad)

The state of Kansas is to be added to the range of this species. I have examined fifteen females and twelve males collected in Seward county, Kansas, July 21.

Dasymutilla nigripes (Fabricius)

1787. *Mutilla nigripes* Fabricius, Mantissa Insectorum, Vol. 1: 313, female.
1897. *Mutilla macra* Fox, Trans. Amer. Ent. Soc., Vol. 25: 245, male (in part).
1912. *Dasymutilla segregata* Rohwer, Proc. U. S. Nat. Mus., Vol. 41: 459, female.
1928. *Dasymutilla sparsa* Mickel, Bull. U. S. Nat. Mus., No. 143: 88-93, Fig. 6, male (nec female).
1928. *Dasymutilla sparsa* var. *segregata* Mickel, Bull. U. S. Nat. Mus., No. 143: 93-96, Fig. 4, female.

Holotype.—Female, without locality label, in Zoologisches Institut d. Universität, Kiel, Germany.

Through the courtesy of Dr. H. Bischoff, Berlin, Germany I have had an opportunity of examining colored plates of the Fabrician and Burmeister types of Mutillidae. These unpublished colored plates are the property of the Lübeck Museum. When I saw the plate of *Mutilla nigripes* F. I was struck by its resemblance to *Dasymutilla sparsa* (Fox) and *D. sparsa* var. *segregata* Rohwer. Dr. O. Schroeder of the Kiel Museum made it possible for me to examine the Fabrician type.

The type is in very poor condition; the abdomen except the first segment is entirely gone; the head is a little more than one-third eaten away by museum pests; but the thorax, legs and first abdominal segment are in good condition. I have compared the parts that are still present with corresponding parts of specimens of *sparsa* var. *segregata*, and there can be no question but that the two are the same. The shape and puncturation of the thorax, the absence of the scutellar scale, the shape of the head and eyes, and shape and puncturation of the first abdominal segment are the same in the type as in specimens of *D. sparsa* var. *segregata* Rohwer from the eastern United States.

Fabricius was mistaken in naming the Orient as the type locality of this species. There is no oriental, or eastern Mediterranean species with eyes and thorax like the type specimen. The type locality should have been stated as "North America." The type specimen came from the Forskahl collection. Forskahl himself was never in North America so that it is probable he received the specimen from some other collector and then sent it to Fabricius.

The synonymy of this species is therefore as follows:

D. nigripes Fabricius becomes the type form with synonymy as above.
D. sparsa Fox becomes a variety of *nigripes* with synonymy as below.

Dasymutilla nigripes var. **sparsa** (Fox)

1897. *Mutilla sparsa* Fox, Trans. Amer. Ent. Soc., Vol. 25: 240, female.
1928. *Dasymutilla sparsa* Mickel, Bull. U. S. Nat. Mus., No. 143: 88–93, Fig. 5, female (nec male).

Dasymutilla macra (Cresson)

The following records extend the range of this species to Illinois: male, Meredosia, August 19, 1913; male, Havana, August 18, 1904 (Hart and Brown).

Dasymutilla stevensi Mickel

1928. *Dasymutilla stevensi* Mickel, Bull. U. S. Nat. Mus., No. 143: 99–101, female.
1928. *Dasymutilla medora* Mickel, Bull. U. S. Nat. Mus., No. 143: 101–102, male, Pl. 1, Fig. 6.

I am now convinced that *medora* is the male of *stevensi*. The latter has a somewhat peculiar distribution: North Dakota, South Dakota, Iowa, Nebraska, Kansas, Colorado, Texas, New Mexico, Arizona and Utah. Specimens of *medora* were known from North Dakota, Kansas, Texas and New Mexico. Since 1928 I have received a series of both *stevensi* and *medora* taken by Mr. C. N. Ainslie at Sioux City, Iowa at the same time and place, and just recently I have received specimens of both from Mr. W. W. Jones taken at Douglas, Arizona. None of these specimens were taken *in copula* but the coincidence of the geographical distributions of the two and the series of specimens taken at Sioux City, Iowa and Douglas, Arizona seem good proof that the two are sexes of the same species.

Dasymutilla dionysia Mickel

A third specimen of this species comes from: Tucson, Arizona, September 1, 1925, female.

Dasymutilla vesta var. **sappho** (Fox)

Additional records are: female, Hardeeville, South Carolina, September 12, 1931 (Bradley and Knorr); female, Pass Christian, Mississippi, June 14, 1917.

Dasymutilla zelaya (Blake)

The following records from Oklahoma are new: male, Wichita National Forest, June 27, 1932 (R. D. Bird); male, Mt. Scott, October 12, 1930 (H. Mathewson).

Dasymutilla myrice Mickel

The type material of this species came from Kansas, Nebraska and Texas. The following records from Colorado and Oklahoma are of interest: COLORADO: male, Burlington, July 27, 1933 (Rodeck and James); three males, Chivington, July 28, 1933 (Rodeck and James); six males, Eads, July 29, 1933 (Rodeck and James); male, Lamport, August 2, 1933 (Rodeck and James); male, Two Buttes, August 2, 1933 (Rodeck and James); two males, Tobe, August 4, 1933 (Rodeck and James); eight males, (Fleck). OKLAHOMA: three males, Woods county, July 20 to 22, 1930 (R. D. Bird); male, Cleveland county, October, 1929 (R. D. Bird).

Dasymutilla coccineohirta (Blake)

The following records extend the range of this species: three females, Parma, Idaho, July 24, 1925, August 1, 1925 and August 13, 1926 (R. W. Haagele); female, Boise, Idaho, July 15, 1921 (C. Wakeland); female, two males, Boise, Idaho (J. M. Aldrich); female, Toppenish, Washington, July 17, 1925 (Walter Carter); female, Walla Walla, Washington, June 23, 1930 (A. L. Strand).

Dasymutilla clytemnestra (Fox)

The following records are new: female, Ashland, Oregon, March, 1916; female, Bakersfield, California, July 14, 1929 (P. W. Oman); female, Olancha, California, August 6, 1931 (E. R. Tinkham); female, Idyllwild Road, California, July 22, 1930 (R. H. Painter).

Dasymutilla bioculata (Cresson)

The following records are from states not represented in the localities listed by me (1928): two males, The Dalles, Oregon, July 17, 1929 (H. A. Scullen); three males, Arlington, Oregon, July 15, 1931 (J. Nottingham and R. H. Beamer); male, Biggs, Oregon, July 16, 1931 (J. Nottingham); male, Pollock, Idaho, July 1, 1907 (J. M. Aldrich); male, two females, Clay county, Missouri, August 30, 1927 (L. A. Stephenson).

Dasymutilla ursula var. **chiron** (Blake)

My opinion is that this variety is a good species and that *melanippe* Mickel is the female sex. Since I have no definite proof that this is the case I refrain from making any nomenclatorial changes. The following records are new: male,

Carrizo Springs, Texas, June 16, 1928 (W. A. Frazier); male, Dilley, Texas, May 5, 1920; two males, Bexar county, Texas, October 6, 1932 (H. B. Parks); male, Bexar county, Texas, July 1, 1933 (H. B. Parks).

Dasymutilla melanippe Mickel

1928. *Dasymutilla melanippe* Mickel, Bull. U. S. Nat. Mus., No. 143: 152–153, female.
1928. *Dasymutilla lauta* Mickel, Bull. U. S. Nat. Mus., No. 143: 154–155, female.

I have had an opportunity of examining a series of fifty-two specimens of this species collected in Bexar county, Texas, 1933 by Prof. H. B. Parks. The specimens vary in length from eight to eighteen mm. The smaller specimens are identical with *lauta*, so the latter name must fall as a synonym. The smaller specimens have the weak carina on the antennal scrobes above practically obsolete. A distinguishing character of this species not mentioned in the original description is the color of the integument of the second abdominal tergite. The latter is more or less ferruginous, not entirely black; usually there is a transverse area on the posterior half of the tergite ferruginous but this may be extended in some specimens to cover the whole disk of the tergite. The color of the integument of the head and thorax varies from black to a dark mahogany red. The types of *lauta* were small specimens, with the head and thorax dark mahogany red and the ferruginous area of the second tergite extended over the whole disk.

Specimens have been examined from Victoria, Karnes, Dimmit, Bexar, Travis and Brooks counties, in Texas.

Dasymutilla alesia Banks

The following records extend the range of this species: two females, Goreville, Illinois, August 19, 1900 (C. A. Hart); female, Grand Tower, Illinois, August 25, 1889; female, Clark county, Indiana; two females, Latimer county, Oklahoma, July 13 and July 16, 1931 (W. Fisher); female, Sherborn, Massachusetts, October 3, 1923.

Dasymutilla biguttata (Cockerell)

The following record is new: female, Natchitoche county, Louisiana, August 16, 1928 (A. M. James).

Dasymutilla curticeps Mickel

Specimens examined: four females, Bexar county, Texas, August 4, 1933 (H. B. Parks); eight females, Bexar county,

Texas, August 30, 1933 (H. B. Parks); female, Texas (Boll); female, Texas.

Dasymutilla nitidula var. **nigridia** n. var.

Female.—Exactly like *nitidula* in form and sculpture but differs in having all the abdominal tergites clothed with black pubescence and in the pair of pale spots on the second tergite averaging smaller in size.

Holotype.—Female, Colorado county, Texas, July 18, 1922 (Grace O. Wiley), in University of Minnesota collection.

Paratypes.—Female, Colorado county, Texas, May 11, 1922 (Grace O. Wiley); two females, Bastrop county, Texas; female, Brazos county, Texas, November 1, 1927; female, Bexar county, Texas, August 1, 1932 (H. B. Parks); two females, Bexar county, Texas, August 10, 1933 (H. B. Parks); twenty-one females, Bexar county, Texas, August 30, 1933 (H. B. Parks); female, Bexar county, Texas, September 11, 1931 (H. B. Parks); female, Bexar county, Texas, September 13, 1933 (H. B. Parks); female, Bexar county, Texas, October 1, 1932 (H. B. Parks); female, Bexar county, Texas, October 2, 1932 (H. B. Parks); two females, Bexar county, Texas, October 6, 1932 (H. B. Parks); female, Bexar county, Texas (H. B. Parks); two females, Texas.

The species *nitidula* was originally described from Oklahoma and Kansas material together with one Texas specimen which was mentioned as having "the pubescence and fringes of all the tergites black." A large part of the Texas material I have seen (Bastrop, Brazos, Colorado and Bexar counties) is like the specimen mentioned as exceptional in the original description. They differ not only in the color of the pubescence of the tergites but also in the fact that the pale yellow spots of the second tergite are more or less reduced in size, more so in some specimens than others. Typical specimens of *nitidula* occur at the same time and place as the variety *nigridia*. Both forms have been taken in Bexar county by H. B. Parks, although *nigridia* is the most numerous. Under these circumstances I prefer to give *nigridia* the status of a variety, rather than a subspecies.

Dasymutilla campanula Mickel

A third specimen of this species is in the Kansas University collection: female, Stanton county, Kansas (S. J. Hunter).

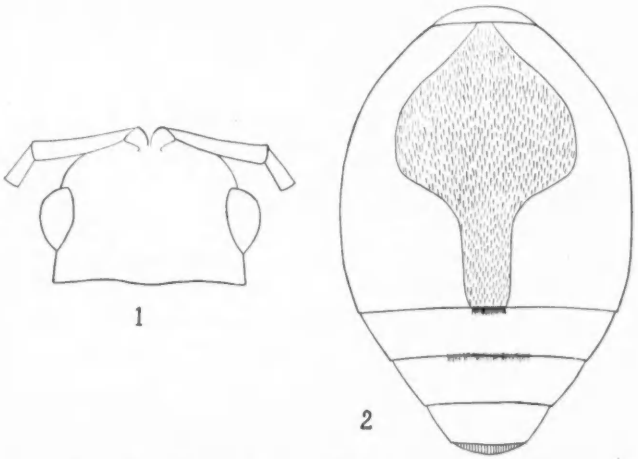
Dasymutilla corcyra Mickel

A third specimen of this species has been collected by Professor H. B. Parks: female, Bexar county, Texas, September 13, 1933.

Dasymutilla beameri n. sp.

(Figs. 1 and 2)

Female.—Entirely dark ferruginous; head squarely truncate behind the eyes, the postero-lateral angles prominently angulate; propodeum with a thin brush of pubescence, the part on the dorsal face of propodeum blackish, the part on the posterior face pale; second tergite clothed with



FIGS. 1 AND 2. *Dasymutilla beameri* n. sp., female holotype. 1, Dorsal view of head. 2, Color pattern of abdomen; pale pubescent except where black is indicated on Figure 2 by shading on segments 2 and 3.

sparse, pale pubescence except a large, median, subconical spot on the anterior two-thirds connected to the posterior margin by a median stem, with sparse, black pubescence; apical fringes of all the tergites pale, except the second narrowly interrupted medially with black, and the third with the median fifth black; pygidial area distinctly longitudinally striated. Length, 12 mm.

Head ferruginous, clothed with sparse, pale pubescence, except the front and vertex clothed with sparse, ferruginous pubescence; mandibles slender, edentate at the apex and with a small, inconspicuous tooth within remote from the apex; clypeus elevated posteriorly into a sharp, transverse, low, sinuate ridge; antennal tubercles approximate; scape densely punctate above; first segment of flagellum slightly shorter than segments two and three united; antennal scrobes not at all carinate

above; front and vertex with moderate, dense, confluent punctures, the genae with the punctures close, less dense than on the front and vertex; posterior margin of head squarely truncate, slightly sinuate, the postero-lateral angles very prominent, each bearing a prominent, subreniform, glabrous tubercle; distance between the eye margins and the postero-lateral angles half the greatest diameter of the eyes; relative widths of head and thorax, 4.7–5.0.

Thorax entirely dark ferruginous, the dorsum clothed with sparse, very dark ferruginous pubescence, the pleural areas with sparse, pale pubescence, the propodeum with a thin pubescent brush as described above; thorax one and one-half times as long as broad; humeral angles not prominent; relative widths of thorax at humeral angles, anterior spiracles, prepropodeal constriction and propodeal spiracles, 3.9–5.0–4.4–4.8; dorsum of thorax with moderately large, dense, confluent punctures; mesonotal area and propodeum separated by a transverse, tripartite ridge, the median part equivalent to the scutellar scale; dorsum of propodeum coarsely punctured, somewhat transversely rugose; posterior face of propodeum with moderately large, separated punctures interspersed with fine punctures; propleurae with large, dense, confluent punctures; anterior half of mesopleurae finely punctate, the posterior half with coarse, confluent punctures; dorsal half of metapleurae glabrous, impunctate, the ventral half with moderate, close punctures; sides of propodeum with moderately large, close, only slightly confluent punctures.

Abdomen entirely dark ferruginous, clothed throughout with sparse, pale, glittering pubescence except as described above for the second tergite, the apical fringes of all the tergites and sternites pale except as described above for the second and third tergites; first tergite with moderate, separated punctures becoming close posteriorly; second tergite with moderate, dense, confluent punctures throughout, the punctures densest along the median line, becoming slightly larger and slightly less dense towards the lateral margins; tergites three to five with moderately small, dense, confluent punctures; pygidial area large, distinctly longitudinally striate, the striae extending to the distal margin; first sternite with a pair of median, subparallel, longitudinal carinae united anteriorly; second sternite with moderately large, distinct punctures, becoming smaller, dense and confluent anteriorly; sternites three to five and the hypopygium with moderately small, dense punctures.

Legs dark ferruginous, sparsely clothed with pale, glittering pubescence, the spines black; calcaria dark.

Holotype.—Female, Wildwood, Florida, August 2, 1930 (R. H. Beamer), in University of Kansas collection.

Related to *anguliceps*, *campanula* and *corcyra*. The shape of the head (truncate posteriorly) is like that in the three aforementioned species; it differs from *campanula* and *corcyra* in the bicolored pubescent brush of the propodeum, and in the color pattern of the pubescence on the abdominal tergites.

Differs from *anguliceps* in the darker ferruginous color, the presence of a propodeal brush, and in the pubescent color pattern of the abdominal tergites.

Dasymutilla parksi n. sp.

Female.—Head very dark ferruginous, almost black; thorax bright ferruginous; abdomen black, the second tergite with a single pair of slightly transverse, yellowish spots on the distal half; head squarely truncate behind, the postero-lateral angles prominently angulate, the truncated margin distinctly sinuate; propodeum with a thin brush of glittering, ferruginous hairs at the junction of the dorsal and posterior faces; all the tergites with a complete apical fringe of pale hairs; pygidial area longitudinally rugose, the rugae not extending to the distal margin. Length, 11.5 mm.

Head very dark ferruginous, almost black, clothed with sparse, pale, glittering pubescence, except the front and vertex with sparse, glittering, ferruginous pubescence; mandibles slender, edentate at the apex, apparently not toothed within; clypeus elevated posteriorly into a sharp, thin, sinuate ridge; scape above with small, dense punctures; first segment of flagellum longer than the second, but shorter than the second and third united; antennal scrobes not carinate above; front and vertex with moderate, very dense, confluent punctures; genae with moderate, distinct, mostly separated punctures; postero-lateral angles with a conspicuous, subreniform, glabrous tubercle; posterior margin of head as described above; relative widths of head and thorax, 4.2–4.4.

Thorax bright ferruginous, the dorsum clothed with sparse, glittering, ferruginous pubescence, the pleural areas with sparse, pale pubescence, and the propodeum as described above; humeral angles rounded, not prominent; thorax widest at the anterior spiracles; relative widths of thorax at humeral angles, anterior spiracles, constriction of mesothoracic area, and at propodeal tubercles, 3.6–4.4–3.8–4.0; scutellar scale present; mesonotal scutellar suture indicated by transverse, interrupted ridges, almost aligned with scutellar scale; dorsum of thorax with moderately large, dense, confluent punctures; dorsum of propodeum coarsely, densely punctate, obscurely, transversely rugoso-punctate; posterior face of propodeum closely punctate, much less coarsely sculptured than the dorsum; propleurae distinctly, closely punctate anteriorly, obscurely, finely punctate posteriorly; anterior half of mesopleurae finely punctate, the posterior half with moderate, close, confluent punctures; dorsal half of metapleurae glabrous, impunctate, the ventral half with moderate, close punctures; sides of propodeum with moderately large, close, somewhat confluent punctures.

Abdomen entirely black, except the second tergite with a pair of subcircular slightly transverse, yellowish spots; abdomen clothed throughout with sparse, pale pubescence, and scattered, erect, fuscous hairs, except the disk of second tergite with sparse, fuscous pubescence; apical fringes of all the tergites pale; first tergite with moderate, close, more or less confluent punctures; second tergite with moderate, very

dense punctures anteriorly, becoming less dense posteriorly, and less dense and larger laterally; tergites three to five with moderate, dense, confluent punctures; pygidial area granulate throughout and longitudinally rugose, the rugae not extending to the distal margin; first sternite with a median, longitudinal carina on the anterior half; second tergite with moderate, distinct punctures, the latter becoming close and confluent on the anterior fifth; sternites three to five posteriorly, and the hypopygium with small, dense punctures.

Legs black, clothed with sparse, pale pubescence; calcaria fuscous.

Holotype.—Female, Bexar county, Texas, September 15, 1931 (H. B. Parks), in University of Minnesota collection.

This species is related by the form of the head and thorax to *anguliceps*, *campanula*, *corcyra* and *beameri* but differs in the rugose pygidial area, the black abdomen with the pair of yellowish spots on the second tergite, and in the complete, pale, apical fringes of all the tergites.

Dasymutilla californica var. **clio** (Blake)

The following records are new: female, Ontario, Oregon, August 1, 1924 (H. A. Scullen); female, Dixie, Oregon, July 8, 1931 (R. H. Beamer); two females, Parma, Idaho, July 23, 1929 and July 19, 1925 (J. F. Bock); female, Tamarack, Idaho, July 24, 1926 (G. W. Haug); female, Stanley, Idaho, July 10, 1926 (R. W. Haagele).

Dasymutilla hersilia n. sp.

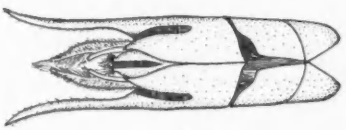


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FIG. 3. *Dasymutilla hersilia* n. sp. Genitalia of male holotype.

Male.—Black, clothed with black pubescence, except the second abdominal tergite largely ferruginous; occiput with distinct, lateral depressions, leaving the median area elevated; anterior face of pronotum emarginate medially; last abdominal tergite with a fringe of hairs at the distal margin; second abdominal sternite with a small, median pit, densely filled with erect, black hairs; second sternite very closely punctate, the anterior third densely, coarsely, confluently punctate. Length, 13 mm.

Head entirely black, clothed throughout with black, erect pubescence; mandibles edentate at the tip and with a small tooth within; clypeus with small, dense punctures, the anterior margin distinctly

bidentate medially; antennal tubercles slightly separated; scape densely punctate, bicarinate beneath, the anterior carina prominent, sharp, the posterior one almost obsolete; first segment approximately two-thirds the length of the second (viewed from beneath); antennal scrobes distinctly carinate above; front, vertex and genae with moderate, dense, confluent punctures, densest on the front; occiput as above; relative widths of head and thorax at the tegulae, 3.7–4.5.

Thorax entirely black, clothed throughout with black erect and suberect pubescence; anterior face of pronotum slightly but distinctly emarginate medially; pronotum, mesonotum and scutellum with dense, deep, confluent punctures; lateral lobes of scutellum densely punctate throughout; dorsum and posterior face of propodeum with large, dense, confluent punctures, scarcely subreticulate; anterior margin of propleurae defined by a carina; propleurae with moderate, close punctures interspersed with fine punctures; mesopleurae with moderately large, close, confluent punctures; metapleurae glabrous with indistinct, fine punctures except ventrally with moderate, close punctures; sides of propodeum with moderately large, close, more or less confluent punctures; tegulae convex, glabrous, impunctate except the anterior and inner margins punctate and black pubescent.

Abdomen black, clothed throughout with black pubescence, except the second tergite largely ferruginous; anterior fourth, posterior eighth and narrow lateral margins (i.e. laterad of felt line) of second tergite black, the remainder ferruginous and mostly clothed with ferruginous pubescence; anterior and posterior margins of ferruginous area angulately emarginate medially; first abdominal segment strongly nodose; first tergite with moderate, close, confluent punctures; second tergite with moderate punctures, distinct and separated anteriorly, sparser medially and posteriorly, dense and confluent at the distal margin; tergites three to six with moderate, dense, confluent punctures; pygidial area with a median, logitudinal, low ridge, elsewhere obscurely longitudinally rugose, the distal margin with a fringe of hairs; first sternite densely punctate, with an indistinct, median, longitudinal carina on the anterior three-fourths; second sternite densely, confluently punctate on the anterior third, the punctures close and slightly confluent elsewhere; the small pit of second sternite median in position; sternites three to six with small, close punctures at the distal margin; hypopygium with moderately small, distinct punctures.

Wings dark fuliginous; cell 2nd $R_1 + R_2$ broadly, squarely truncate at the apex; veins r-m + Rs and R_5 separated, the distance between them equal to the length of vein r; cell R_5 receiving vein M_{3+4} distinctly before the middle; cell R_4 obsolete.

Legs black, sparsely clothed with black pubescence; calcaria black.

Holotype.—Male, Bexar county, Texas, August 4, 1933 (H. B. Parks), in University of Minnesota collection.

Superficially this species is indistinguishable from *permista*, *meracula*, *vesta* and other males of similar appearance. It is most closely related to *hora* and runs out near that species in the key to the males of *Dasymutilla* (Mickel, 1928). It

differs from other males than *hora* by the fringe of hairs at the distal margin of the last tergite and by the coarsely punctate anterior third of the second sternite. It differs from *hora* in the median position of the pit on the second sternite and in the black color of the same sternite. The genitalia, Fig. 3, are of the same general type as in *hora* but differ in the shape of the volsella, the distal half being much more slender in *hora* than in *hersilia*.

Dasymutilla castor (Blake)

Specimens examined: male, Leroy, Alabama, June 11–12, 1917; three males, Batesburg, South Carolina, August 24, 1930 (J. Nottingham and L. D. Tuthill); male, New Orleans, Louisiana.

Dasymutilla gentilis Mickel

Two specimens have been seen since the holotype was described: male, Kiowa county, Kansas, July 4, 1923 (L. C. Woodruff); male, Rocky Mountains (Allaud).

Dasymutilla meracula Mickel

Numerous specimens of this species from Bexar county, Texas have been seen since the species was described. A single specimen from Oklahoma is at hand: male, Major county, June 28, 1930 (R. D. Bird).

Dasymutilla polia Mickel

Specimens examined: male, Tonto N. Mon, Arizona, July 26, 1932 (R. H. Painter).

Dasymutilla arcana Mickel

Additional records are: NEBRASKA: male, Meadow Grove, July 18, 1929 (C. N. Ainslie). COLORADO: male, Boulder county, August 5, 1926 (C. H. Hicks); male, Valmont, June 5, 1926 (C. H. Hicks); male, Lolita, August 8, 1933 (Rodeck and James).

Dasymutilla calorata Mickel

Specimens examined: KANSAS: female, Beaumont, June 29, 1889. OKLAHOMA: two females, Woodward, July, 1925; four females, Woods county, July 18, and July 19, 1930 (R. D. Bird). TEXAS: female, Big Bend Red., 1928 (F. F. Bibby); three females, Brewster county, June, 1929 and 1931. NEW MEXICO: female, Chaves county, July 8, 1927 (L. A. Anderson).

Dasymutilla klugioides n. sp.

Female.—Entirely black, clothed with black pubescence, except the pubescence of abdominal tergites two to five, and the distal fringes of sternites two to four, fulvous; antennal scrobes not at all carinate above; posterior margin of genae defined by a carina; thorax slightly longer than broad; scutellar scale present but weakly developed; pygidial area longitudinally striate. Length, 16 mm.

Head entirely black, clothed throughout with sparse, black pubescence; mandibles slender, edentate at the apex, and with a small tooth within remote from the apex; clypeus elevated posteriorly into a transverse, sharp, sinuate carina; antennal tubercles approximate, densely punctate; scape closely, coarsely punctate; first segment of flagellum slightly less than twice as long as the second; antennal scrobes not at all carinate above, the puncturation of the front extending onto the scrobes; front and vertex coarsely punctate, with large, dense, confluent punctures; genae less coarsely punctate, with moderate, close, confluent punctures, the posterior margin defined by a distinct carina; relative widths of head and thorax, 5.6–7.3.

Thorax slightly longer than broad, entirely black, clothed throughout with sparse, black pubescence; humeral angles obscurely angulate; dorsum of thorax coarsely punctate, with very large, deep, dense, confluent punctures; scutellar scale present but weakly developed; dorsum and posterior face of propodeum coarsely, deeply punctate, except the disk of the posterior face with the punctures moderate, dense and confluent; propleurae with the anterior margin defined by a carina, and with scattered large punctures intermixed with small, close punctures; anterior third of mesopleurae finely punctate, the posterior two-thirds coarsely, confluently punctate; metapleurae mostly glabrous, impunctate except for scattered punctures ventrally; sides of propodeum with moderately large, close punctures.

Abdomen entirely black, clothed with black pubescence, except the pubescence of tergites two to five, the pygidial tergite, and the distal fringes of sternites two to four, fulvous; first tergite with dense, confluent punctures; second tergite with large, close, confluent punctures; tergites three to five with moderate, dense, confluent punctures; pygidial area longitudinally striate; first sternite elevated along the longitudinal midline, higher anteriorly than posteriorly; second sternite with moderate, distinct punctures; sternites three to five with small, dense, confluent punctures distally.

Legs black, sparsely clothed with black pubescence; calcaria black.

Holotype.—Female, Major county, Oklahoma, June 28, 1930 (R. D. Bird), in University of Minnesota collection.

Very similar in appearance to *klugii* (Gray) but differs as follows: antennal scrobes not at all carinate above; genae less coarsely punctured than the front and vertex; scutellar scale weakly developed; thorax less definitely longer than broad; and distal fringes of sternites two to four fulvous, not black.

Dasymutilla hispidaria n. sp.

1928. *Dasymutilla klugii* Mickel, Bull. U. S. Nat. Mus., No. 143: 229–231, female (in part).

Female.—Black, clothed throughout with brownish fulvous, glittering pubescence, that on the head and thorax sparser and paler, except the tarsi and hind tibiae clothed for the most part with black pubescence; antennal scrobes strongly carinate above; genae as coarsely sculptured as the front and vertex, the posterior margin subcarinate; pygidial area longitudinally rugose, almost striate. Length, 20 mm.

Head black, clothed throughout with sparse, semi-erect, very pale fulvous, glittering pubescence; mandibles slender, edentate at the apex and with a small tooth within remote from the apex; clypeus elevated posteriorly into a transverse, sharp, sinuate ridge; antennal tubercles large, prominent, approximate, coarsely rugose; scape above with moderate, close punctures; first segment of flagellum much longer than the second, but shorter than the second and third segments united; antennal scrobes strongly carinate above; front, vertex and genae with moderately large, dense, confluent punctures; posterior margin of genae subcarinate; relative widths of head and thorax, 6.0–8.0.

Thorax black, clothed throughout with erect and appressed, very pale fulvous, glittering pubescence; thorax much longer than broad; humeral angles subangulate; scutellar scale present and well developed; dorsum with large, coarse, dense, confluent punctures; posterior face of propodeum with the punctures smaller, less coarse and less dense posteriorly; propleurae defined anteriorly by a strong carina, with large, close, confluent punctures; anterior half of mesopleurae micropunctate and with the pubescence appressed, the posterior half coarsely, confluently punctate with the pubescence long and erect; metapleurae glabrous, impunctate except ventrally with large, confluent punctures; sides of propodeum with large, confluent punctures.

Abdomen black, clothed throughout with erect and appressed dull fulvous glittering pubescence, thickest on the dorsum; coarsely punctate throughout, the punctures on the second segment larger than on the remaining segments; pygidial area longitudinally rugose, almost striate; first sternite with a median, longitudinal carina on the anterior half, the carina elevated into a prominent tooth anteriorly.

Legs black, clothed with sparse, brownish fulvous, glittering pubescence, except all the tarsi and the hind tibiae clothed mostly with black pubescence; calcaria black.

Holotype.—Female, Cat. no. 50641 U. S. N. M., Hondo, Texas, May 20, 1906 (J. D. Mitchell).

Paratype.—Female, Texas.

Related to *klugii*, *calorata* and *clotho* but differs in having the body clothed entirely with brownish fulvous pubescence, the sides of thorax, the propodeum and abdominal sternum being concolorous with the rest of the body. In this respect it agrees with *satanas* but the latter has the genae less coarsely

sculptured than the front, the posterior margin not carinate, and the pubescence is much longer and usually paler than in *hispidaria*.

Dasymutilla gloriosa (Saussure)

1867. *Mutilla gloriosa* Saussure, Ann. Soc. Ent. France, ser. 4, Vol. 7: 359, Pl. 8, Figs. 9 and 9a, female.
1875. *Mutilla tecta* Cresson, Trans. Amer. Ent. Soc., Vol. 5: 119, female.
1928. *Dasymutilla gloriosa* Mickel, Bull. U. S. Nat. Mus., No. 143: 242, female.
1928. *Dasymutilla reperticia* Mickel, Bull. U. S. Nat. Mus., No. 143: 287, Pl. 4, Fig. 34, male.

Dr. J. Chester Bradley has sent me a gynandromorph specimen of this species for examination, with the suggestion that I might be able to determine the name under which the male sex of this species has been described. In spite of the fact that characters upon which a conclusion regarding the male may be made are limited to two abdominal tergites in the gynandromorph specimen, it is possible to determine the name of the male sex. My reasoning and conclusions are as follows: Since the male area of the gynandromorph specimen has orange-yellow pubescence on the posterior portion of the second tergite, nearly all of the third tergite and part of the fourth tergite, the true male must belong to the group of species which have the pubescence on the third to sixth tergites concolorous with that on the posterior portion of the second. There are several such males, a part of which have only the apical fringe of the second tergite orange-yellow, and a few which have the posterior half of this tergite clothed with orange-yellow pubescence. The gynandromorph specimen has most of the posterior half of the male area of the second tergite with orange-yellow pubescence, so it must belong to the latter group of species. Another characteristic further restricting the number of species concerned is the fact that in the gynandromorph specimen the discal portion of the male side of the second tergite has a large part of the pubescence partly recumbent or suberect, at least noticeably directed posteriorly. Most of the species of males with the apical half of the second tergite orange-yellow pubescent have the pubescence entirely erect. These three characters point to the probability that the male *reperticia* Mickel is the male of *gloriosa* Saussure, and with that in mind I have carefully checked the holotype and several paratypes of *reperticia* with the gynandromorph specimen with respect to the first four abdominal segments. I have interpreted

the anterior area of the male part of the second tergite of the gynandromorph, which is reddish-brown with brownish pubescence, as being black in a normal male specimen. Even in some normal specimens of black species of Mutillids, the black color is sometimes weak and takes on a reddish brown appearance. From my experience in studying thousands of specimens of *Dasymutilla* and other Mutillid genera, this is an entirely legitimate interpretation. So interpreted, the puncturation, color pattern, color of pubescence and character of pubescence are alike in the gynandromorph specimen and the male specimens of *reperticia*. There is no more variation, and there is sometimes less, between the gynandromorph and *reperticia* than there is between the various type specimens of the latter. The fact is also of some value as evidence that three of the localities and dates recorded for *gloriosa* by me in 1928 are the same as three of those recorded for *reperticia*, as follows: Catalina Mts., Arizona, June 13, 1903 (Oslar); Patagonia Mts., Arizona, May 15, 1903 (Oslar); and Comobabi Mts., Arizona, August 9–10, 1916.

The name *reperticia* Mickel then falls as a synonym of *gloriosa* Saussure, the pertinent synonymy and references being as above. The type of *gloriosa* Saussure is at the Muséum d'Histoire Naturelle, Geneva, Switzerland instead of at Paris as suggested by me in 1928. I have had the opportunity of examining the type and it agrees with the specimens determined by various authors as *gloriosa*. I take this opportunity of acknowledging the kindness of Dr. J. Chester Bradley in sending the gynandromorph specimen to me for study.

Dasymutilla asteria n. sp.

Female.—Ferruginous, the head, pronotum, propodeum, except a median dorsal black spot and the sides, pleural areas, median longitudinal third of first tergite, all clothed with dense, more or less appressed white pubescence; distal margin of first and second tergites with a dense, complete fringe of white pubescence, the fringe of the third and fourth tergites broadly interrupted medially with black, that of the fifth tergite black; disk of anterior half of second tergite clothed with sparse, erect, black hairs and sparse, appressed, glittering scarlet hairs; disk of posterior half of second tergite clothed with sparse, erect and appressed, black hairs; second tergite with a pair of transverse, sublunate spots of sparse, white pubescence at the junction of the scarlet and black appressed hairs of the anterior and posterior halves; posterior margin of genae defined by a carina; scutellar scale present; pygidium distinctly longitudinally striate. Length, 11 mm.

Head ferruginous, clothed throughout with erect and appressed, white pubescence, dense on the front and vertex, somewhat sparse on the genae; clypeal fringe of long fuscous hairs and short white hairs intermixed; posterior inner margins of eyes with a few, very long, erect, black hairs; mandibles slender, the distal half blackish, edentate at the tip and apparently with a small tooth within remote from the apex; clypeus elevated posteriorly into a transverse, sinuate, sharp carina, slightly angulate at the median line; antennal tubercles prominent, contiguous; scape clothed with sparse, white pubescence; first segment of flagellum slightly longer than the second, shorter than the second and third united; antennal scrobes defined above by a distinct carina; sculpture of front and vertex apparently coarsely, confluently punctate, obscured by the dense pubescence; genae with large, close, confluent punctures, defined posteriorly by a distinct carina; relative widths of head and thorax, 3.9–4.1.

Thorax ferruginous, clothed with thick, erect and appressed, white pubescence, except the sides of propodeum practically bare, the mesonotum with erect and appressed, black pubescence, a median, dorsal, longitudinal area on the propodeum connecting with the mesonotal area, of black pubescence, and the dorsum of propodeum with scattered, erect, black hairs throughout in addition to the white pubescence; dorsum of thorax with large, coarse, confluent punctures; scutellar scale well developed; humeral angles rounded; relative widths of thorax at humeral angles, anterior spiracles, middle of mesonotum and propodeal spiracles, 3.4–4.1–4.1–3.3; sculpture of propleurae, mesopleurae and metapleurae largely obscured by the pubescence except the posterior fourth of metapleurae coarsely, confluently punctate; sides of propodeum with large, coarse, contiguous punctures except the dorsal third glabrous, impunctate.

Abdomen ferruginous, except the pygidium black, the venter clothed with sparse, pale pubescence, and distal margins of sternites two, three and four with thick fringes of white hairs, the fringe at the margin of the fifth sternite, pale fuscous; median longitudinal third and distal margin of first tergite clothed and fringed with thick, white pubescence obscuring the sculpture; second tergite with large, coarse, confluent punctures, the latter becoming separated and somewhat less coarse laterally; lateral areas of second tergite with very sparse, erect, pale pubescence; anterior half of disk of second tergite with sparse, erect, black hairs and sparse, appressed, glittering scarlet hairs, the posterior half with sparse, erect and appressed, black hairs, the two halves separated in part by a pair of transverse, sublunate spots of sparse, appressed, white pubescence; third and fourth tergites clothed with sparse, appressed and erect, white hairs, broadly interrupted medially with black hairs, the distal margin of each with a thick fringe of white hairs broadly interrupted medially with black, both tergites with moderately large, dense, confluent punctures; fifth tergite clothed with erect and appressed, black pubescence, and with moderately large, dense, confluent punctures; pygidial segment clothed laterally with erect, black hairs; pygidial area distinctly, longitudinally striated; first sternite with a median, longitudinal carina on the anterior half; second sternite with moderately large, close, slightly confluent punctures.

Legs entirely ferruginous, sparsely clothed with pale, glittering hairs, except the tips of the femora externally with thick, appressed, black hairs; spines and calcaria black.

Holotype.—Female, Pima county, Arizona, September 10, 1925 (T. A. Austin), in University of Minnesota collection.

Related to and very similar in appearance to *sicheliana* (Saussure), but differs from the latter as follows: smaller than the average size of *sicheliana;* black pubescent spot on propodeum of *sicheliana* not connected with black mesonotal area; first tergite of *sicheliana* without appressed, white pubescence, only the apical fringe white; appressed scarlet pubescence of second tergite entirely absent in *sicheliana* and black pubescence of same tergite much sparser than in *asteria;* white fringe at distal margin of second tergite in *sicheliana* produced anteriorly at the middle, not produced in *asteria;* third tergite clothed entirely with white pubescence in *sicheliana*, broadly interrupted in *asteria;* median black pubescent area of fourth tergite much broader in *sicheliana* than in *asteria.*

Dasymutilla chrysocoma Mickel

ARIZONA:—female, Tucson, September 1, 1925; eleven females, Douglas, July 24, 1933, July 25, 1931, August 1, 1933, August 8, 1928, August 15, 1930, August 30, 1932, October 3, 1933 and October 6, 1933 (W. W. Jones).

Dasymutilla errabunda Mickel

ARIZONA:—male, Tempe, August 4, 1917; male, Yuma, May 3–5, 1918 (J. C. Bradley).

Dasymutilla sophrona Mickel

ARIZONA:—three males, Douglas, August 1, 1931, August 7, 1933 and August 29, 1929 (W. W. Jones).

Dasymutilla creon (Blake)

TEXAS:—male, Dickinson, July 16, 1930 (J. N. Roney); two males, Bexar county, September 20, 1931 and October 9, 1930 (H. B. Parks).

Dasymutilla arenivaga var. **unicolor** n. var.

Female.—Exactly like typical *arenivaga* except the pubescence of the abdomen is the same throughout and concolorous with that on the dorsum of the thorax, the front and vertex; no black pubescence on the abdomen. Length, 16 mm.

Holotype.—Female, Ft. Mojave, Arizona, March 14, 1911 (J. Henderson), in University of Minnesota collection.

Dasymutilla megalophthalma Mickel

ARIZONA:—three males, Yuma, August 26, 1931 (E. R. Tinkham); male, Sauceda Mts., August 27, 1931 (E. R. Tinkham). CALIFORNIA: three males, 25 mi. w. of Blythe, August 18–19, 1927; four males, Thermal, August 18–19, 1927; eight males, Palm Springs, September 15 to October 15, 1932 (T. Zschokke) light trap; male, Palm Springs, August 25, 1932 (T. Zschokke).

Dasymutilla phaon (Fox)

TEXAS:—male, Presidio, May 25, 1929 (E. R. Tinkham). UTAH: male, Cottonwood Canyon Bluff, June 26, 1933.

THE MIGRATIONS OF ANIMALS FROM SEA TO LAND, by A. S. PEARSE. pp. i-x, 1-176, 4 figs. 1936. Published by Duke University Press, Durham, North Carolina. Price, $3.00.

We notice this work because on nearly every page it touches on insects and their relatives, the Crustacea. Whether as Crustacea or not the ancestors of insects came out of the sea. The volume is more or less a summary of the ecology of seashore animals which has been one of the interests of the author. It is a compilation of available data on how and why animal life, which most probably originated in the sea, finally evolved out onto dry land.

The material is organized as follows: Chapter I. Introduction; Origin of Life; The Sea as the Original Home, Comparison of Ocean, Freshwater and Land: II. Routes from Sea to Land: III. Causes of Migrations from Sea to Land: IV. Changes in Animals Which Have Migrated from Sea to Land: V. What Land Animals Have Attained. Bibliography. Index.

The author argues no new theories of his own but becomes a thoughtful guide to the reader through the maze of very scattered literature which bears on the subject. It is animal physiology and animal evolution in direct relation to the environment and is of particular value to the biologist in its organization of the data (forty-four pages of references) scattered through zoological and physiological literature. It is a lead into the very poorly organized literature on the comparative physiology of animals.

We read with interest the concluding chapter on What Land Animals Have Attained by evolving out of a stable medium into an unstable one. That "If it is desirable to move speedily and handle problems encountered in the environment with increasing understanding and efficiency, to be progressive, then the struggle to land has been worth while;" further, that human civilization is the "fairest flower of progressive evolutionary growth." The reviewer sometimes doubts, if we are civilized, at least until we pat ourselves on the back less often. At times it seems as though the added troubles encountered by animals on land are almost unbearable especially when one is compelled to take cognizance of the red embellishments on the family budget. Marine animals do not appear to have bothered with family budgets. Could we have been just a little out of luck when the God of Chance hung us on the land side of the evolutionary tree?

Besides being a very useful book in the study of general biology and its own problem in particular, we like it because the author dares suggest speculative answers which to a strict experimentalist may be based on a minimum of fragile data. It is a book with mental room as every page raises problems which suggest further thought and experiment.—C. H. K.

SOME ERYTHRONEURA OF THE OBLIQUA GROUP FROM DECATUR, GEORGIA

(Homoptera, Cicadellidae)

MARY AUTEN,
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From the Fall of 1933 to the Spring of 1934 a collection of Homoptera, especially Erythroneura, was made by the senior author in the vicinity of Decatur, Georgia. In the process of identification there appeared a number of new forms. In this paper members of the Obliqua Group are treated.

Descriptions and figures of inner male genitalia of eight new species are included.

Unless otherwise indicated collections were made in or near Decatur, Georgia, by Dr. Mary Auten.

All specimens will be deposited in the Herbert Osborn Collection at the Ohio State University.

Erythroneura cavena n. sp.

(Fig. 1)

Background opaque white, eyes dark, vittae narrow, dark red. Vertex with irregular narrow inverted V, arms not touching eyes; pronotum with widely separated narrow stripes almost parallel, a little broader toward posterior margin; scutellum, basal angles and tip outlined in red; elytral vittae bright, narrow, distinct, three black elongate smudges before crossveins, apical cells distinctly fumose, veins pale. Below, abdomen dusky, legs yellow, translucent, thorax and head cream washed with pale yellow-orange. Length, 3 mm.

Genitalia: Style with long foot; heel narrow, sharply protruding; base slightly concave; anterior point short, blunt, projecting cephalad; posterior point short, narrow, sharp, one-fourth length of foot, meeting base at right angle curve; oedagus in lateral view long, simple, curved dorsad, swollen on dorsal margin in apical half, constricted before tip and divided into two slender, blunt lateral projections.

One male (holotype), xii–1–33.

Erythroneura scytha n. sp.

(Fig. 2)

Large species, background creamy white, vittae broad, pale orange. Vertex, heavy inverted V, arms bordering eyes and meeting on inner

base leaving a slender ovoid pale space on disc; pronotum with broad irregular vittae beginning below anterior margin and continuing across to posterior margin, divergent on outer side and almost parallel on inner; scutellum, basal angles and apex broadly orange; elytral vittae broad, three small roundish dark spots before apical veins, the outer black, apical cells faintly dusky, subhyaline. Below yellowish white. Length, 3.25 mm.

Genitalia: Style heavy with large foot; heel small, projecting slightly; base straight; anterior point about rectangular; posterior point a little longer than foot, heavy, tapering to rather blunt point and curved evenly in from base to apex which is almost in line with heel; oedagus from lateral view of medium size, shaft curved slightly dorsad, small dorso-caudad apical keel, rather rough triangular ventral projection on basal half, the point about a fourth of distance from base and as broad as shaft at its middle.

One male (holotype), v-8-33.

Erythroneura contrasta n. sp.

(Fig. 3)

Background of vertex and pronotum yellowish white, vittae of head, pronotum and scutellum orange, of elytra scarlet. Vertex with even-sided inverted V, arms very slightly broadened toward eyes; vittae continued across pronotum, inner margins parallel, outer diverging, at posterior margin equal in width to basal angles of scutellum; scutellum, basal angles yellow orange, tip orange; elytra, inner vittae sharply defined, bright and even, costal margin washed with translucent orange yellow, three dusky spots, the outer large, before crossveins; apical cells fumose. Below creamy, washed with orange on face, some outer spines on hind tibiae dark. Length, 3 mm.

Genitalia: Style slender with rather large, heavy foot; heel large, projecting; base somewhat convexly curved; anterior point projecting cephalad, short and sharp; posterior point heavy, as long as base, its outer margin in straight line with that of anterior point, pointed at apex, widening rapidly on outer half, then parallel-sided to base; oedagus in lateral view long, stout at base, curved dorsad, a pair of lateral leaf-like expansions at apex; outer fourth narrowing gradually to apex; pair of slender, blunt-tipped processes arises just ventrad to shaft and follows it closely for three-fourths of its length.

One male (holotype), two females (allotype and paratype), on *Japonica*, iv-6-34.

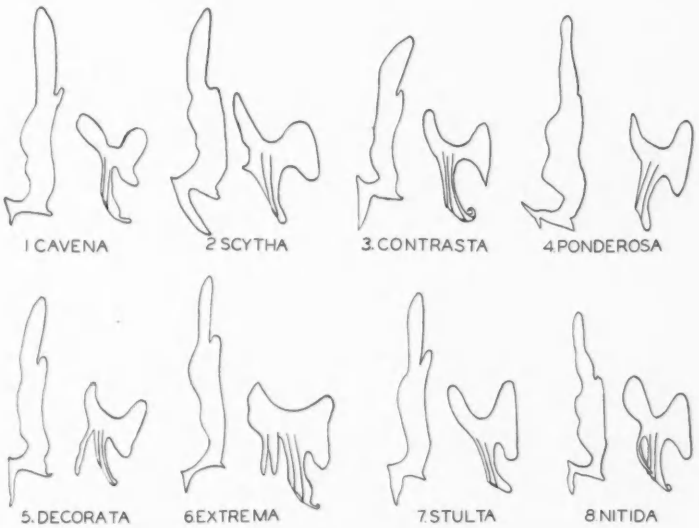
Erythroneura ponderosa n. sp.

(Fig. 4)

Pale species, creamy white background and yellow orange vittae. Vertex with inverted V elongate, arms enlarged toward but not touching eyes; pronotal vittae narrow, distinct, reaching both margins, diverging slightly on outer side toward posterior margin; elytral vittae of medium size and distinct, apices hyaline. Below pale creamy white. Length, 3 mm.

Genitalia: Large heavy style with long foot; heel very large, sharp, projecting; base long, slightly convex at middle; anterior point long, sharp, directed latero-cephalad; posterior point a third length of anterior, sharp, meeting base at about 45° angle; oedagus from lateral view short and stout, with long ovoid keel at apex directed caudad; lacking processes.

One male (holotype), v-3-34.



Figs. 1-8. Ventral view of style and side view of oedagus in new species of Erythroneura.

Erythroneura decorata n. sp.

(Fig. 5)

Slender species with anterior background creamy, white on elytra, vittae orange, scarlet on elytra. Vertex with inverted V enlarged at eyes; pronotum, vittae narrow, distinct, diverging gently toward posterior margin; scutellum, basal angles yellow, darker on margin, apex orange; elytra, broad distinct bright vittae, two small round dusky spots before crossveins, the outer darker; apical cells dusky semi-hyaline. Below pale cream. Length, 3 mm.

Genitalia: Style of medium size with rather narrow foot; heel large, sharp, distinctly projecting; base almost straight; anterior point rectangular; posterior point narrow, straight, as long as base with sharp tip turned out slightly; oedagus from lateral view rather slender, curved

considerably dorsad, with small dorsal keel at apex; pair of narrow, slightly sinuate, blunt processes arises ventrad to base of shaft and extends forward about three-fourths length of shaft.

One male (holotype), on *Japonica*, iv-6-34; two females (allotype and paratype), same data.

Erythroneura extrema n. sp.

(Fig. 6)

A pale stout species with white background, whitish semi-hyaline on elytra, growing more hyaline toward apex, vittae pale orange throughout. Vertex with short, stout inverted V, arms widened to touch eyes, continued across pronotum as parallel-sided, slightly divergent vittae; scutellum, basal angles pale yellowish orange, apex pale orange; elytra with rather broad vittae, that of the clavus deeper orange, the costa translucent yellow orange; apex subhyaline; below creamy white, face pale orange. Length, 3 mm.

Genitalia: Style of medium size with long slender foot; heel small, projecting slightly; base long, curved concavely; anterior point rectangular; posterior point about a third length of foot, sharp, meeting base at considerably more than right angle; oedagus large with broad, straight shaft; ventral margin sinuous, posterior margin inflated on apical half, apex divided into two slender, latero-cephalad directed, blunt projections; pair of widely divergent, thick, blunt processes arises more than its width ventrad to base of shaft and extends a little more than half its length.

Male (holotype), v-3-34; two male paratypes, one same data, one on Holly, ix-24-33; two females (allotype and paratype), v-3-34.

Erythroneura stulta n. sp.

(Fig. 7)

Stout bodied species with lemon-yellow vittae. Background creamy white anteriorly, whitish semi-hyaline on elytra. Vertex short, heavy inverted V, laterally widened toward base, not touching eyes, pale median triangular area much reduced; pronotum, vittae very broad, irregular, not quite attaining anterior margin, a little broader on posterior margin; scutellum, basal angles and tip lemon yellow; elytra, vittae broad, indistinct, costa broadly washed with lemon yellow to crossveins, three dusky blotches before crossveins, apical cells smoky hyaline. Below cream. Length, 3 mm.

Genitalia: Foot small, heavy; heel small, projecting slightly; base short, straight; anterior point subrectangular; posterior point straight, broad, meeting base at right angle, tapering to point; oedagus in lateral view with unadorned shaft of medium size curved gently dorsad with a large ovoid dorsal keel at apex.

One male (holotype), one female (allotype), v-12-34.

Erythroneura nitida n. sp.

(Fig. 8)

Background cream of elytra whitish semi-hyaline; color markings of vertex lemon-yellow, of pronotum and scutellum orange yellow, of elytra orange. Vertex, inverted V with arms enlarged toward eyes, not reaching margin, eyes dark gray; pronotum, irregular slightly divergent vittae reaching posterior but not anterior margin; scutellum, basal angles pellucid orange yellow, tip orange; elytra, claval and corial vittae distinct, of medium width, outer costal stripe pale, indefinite, three elongate smoky blotches before pale crossveins, a little darker than semi-hyaline apical cells. Below cream, beak orange. Length, 2.75 mm.

Genitalia: Style with long foot; heel large, projecting; base straight; anterior point subrectangular; posterior point about half length of foot, rather blunt, curved in a little, slightly wider at middle than base; oedagus in lateral view short and slender, curved dorsad, pronounced apical keel projecting dorso-caudad to opening of tube; pair of processes arises twice its width ventrad to shaft, curves ventrad, then back to shaft, touching it just above mouth of tube.

One male (holotype), McCurdy's Pond, iv-16-34.

PROTOPLASM, by WILLIAM SEIFRIZ. pp. i-x, 1-584, 179 figs. McGraw-Hill Book Company, Inc., New York and London. 1936. Price, $6.00.

"Protoplasm" is a very readable book. Three different evenings have been scheduled for the writing of this short notice and each in turn has been lost in a delightful brouse through its pages. "The presentation is as non-technical as is consistent with accuracy and completeness. Mathematical formulas, curves, and tables have not been omitted—it would be difficult to do so in a number of instances where the subject defies a wholly non-technical presentation—but they have been resorted to as infrequently as possible."

The greater part of the material presented is on colloidal systems, hence physical chemistry in its simplest forms. Some of the twenty-seven chapter headings are as follows: The Living Substance, The Cell, Tissue Culture, The Colloidal State, Emulsions, Hydrophilic Sols and Gels, Surface-Tension, Adsorption, Osmosis, Imbibition, Viscosity, Elasticity, Structure of Protoplasm, Permeability, Acidity, Electrophysiology, Electrokinetics, Radiant Energy, Role of Water, Salts, Carbohydrates, Fats, Proteins, Regulatory Substances, Origin of Living Matter.

We like the bibliography (pages 539–563) as it gives titles of articles and is organized under subject heads, a section for each chapter. The volume closes with twenty pages of index. Thus the volume, as with most McGraw-Hill books, is well organized.

Doctor Seifriz is Professor of Plant Physiology at the University of Pennsylvania, whose research interests have centered around cell function and structure. The work has no special botanical leanings as it is obviously written as a review of the subject for the average biologist. Again quoting the Preface: "A list of references is appended, in case the reader should care to delve more deeply into the subject of this or that chapter." We give it a notice here because of the growing interest among entomologists in general biological problems, and particularly for the group of entomologists, increasing rapidly in numbers, who are studying the effects of insecticides on living insects. It is an interesting book.—C. H. K.

A HISTOLOGICAL STUDY OF THE EYE AND BRAIN OF A ONE-EYED BEE

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Alfonsus (1) has described a curious one-eyed bee which he found in the college apiary in 1930. He describes the appearance and actions of this unusual specimen, but apparently did not subject the specimen to histological treatment in an effort to find out what rearrangement had taken place in the head in order for the brain to adapt itself to the displacement of the eye and other features of the exterior.

Several specimens of Italian bees possessing only one eye apparently similar to the one Alfonsus found were received from the south at this laboratory. A series of sections was made of the heads of these bees. There were several pupae as well as adults of both workers and drones. Unfortunately, the pupae were not far enough advanced for the internal structures to reveal much concerning the final arrangement. The fact that there were so many of these specimens is interesting in the light of Alfonsus' statement that diligent search failed to find a second individual in his hive.

The sections were prepared as follows: The material was killed and preserved in hot Bouin's solution. Then the antennae and mouthparts were snipped off to allow free access of the solutions and the paraffin. The heads were dehydrated in the usual alcohol series, cleared in xylol and imbedded in paraffin. Proper infiltration with the paraffin required several days. The sections were stained with Delafield's haemotoxylin and aqueous eosin. This left the chiasmae a clear pink, while the surrounding tissue, including the fibrillar masses with their heavily stained nuclei, were much darker.

For purposes of comparison sections were also made of the head of a normal worker bee. In these sections the various regions of the normal head were easily recognized and are diagrammed in Figure 1.

In comparing the structure of the normal and abnormal head, the following features were noted:

1. *Ocelli:* Although there is no visible evidence of ocelli on the exterior of head, the ocelli are present within the head, and are com-

plete except for the absence of the cornea, (Fig. 3). Instead of being located on the top of the head, the ocelli are tipped far forward until they reach a position immediately behind the basal antennal segments. This region of the head being already occupied by the antennal cavities is probably the reason for the absence of the corneae. The ocelli seem to rest directly on the protocerebrum, so that there are no ocellar nerves visible, which normally arise between the inner mushroom bodies.

2. *Compound Eye:* As previously stated this bee is peculiar in possessing only one compound eye, located on the top and front of the head, rather than two independent eyes located on the sides of the head. When viewed from without, even with the aid of a powerful microscope, there is no evidence that the eye is the result of the fusion of the two normal eyes, but such evidence is present in a study of the histology. The evidence is found in the presence of two distinct basement membranes, (Figs. 3–6). As in the figures the two membranes are separated by a small space. In accommodation the optic lobes are bent upwards until they lie side by side at the top of the brain. The position assumed by the optic lobe also brings upward the outer and middle fibrillar masses, the outer and middle chiasmae, and the inner fibrillar mass. The inner chiasma, because of its more or less central position remains more nearly in place than any other region of the brain. In locating the chiasmae, the middle chiasma with its typical sausage shape and light colored central band serve as a most important landmark. The sub-retinal nerve bundles seem normally developed, their interstices being filled with minute tracheoles as in the normal bee.

3. The approximation of the optic lobes above the protocerebrum leaves no space for the normal position of the mushroom bodies. These, accordingly are pushed forward and down and lie on either side of the hidden ocelli. The presence of both inner and outer mushroom bodies could not readily be determined, as these bodies suffered much distortion. The presence of both inner and outer forms seems probable, however.

4. In respect to the compound eye itself, the only abnormality seems to be that of location. Of course there may have been abnormality of vision. In fact Alfonsus' paper indicates that visual abnormality may have been the cause of the refusal of the bee to walk in a normal manner, since the normal bee is positively phototropic and Alfonsus' bee would walk only backward. He states that even placing honey before the bee would not cause it to move forward.

5. Some of the ommatidia of the one-eyed bee are much longer than corresponding ommatidia in the normal eye, due to the greater depth of the single eye at the place where fusion takes place. In all probability this would have little effect upon vision in itself, since the ommatidia of the normal eye vary greatly in length. It is also noted that the corona is more densely hairy than is usual, even in a newly emerged bee. This, too, would seem to have little significance in the light of the fact that hairiness becomes less and less noticeable as a bee grows older, until finally an old bee may be entirely de-nuded of hair in the region of the head and thorax.

6. One unusual feature of the one-eyed bee described in this paper is the presence of a pronounced lobe on the front between the bases of the antennae. Extreme hairiness is a feature of this region, also, a fact which is mentioned by Alfonsus, and this dense growth of hair obscures the above mentioned lobe. The lobe is easily revealed, however, if the hair is removed, which may be done by the use of a fine brush, or as in the present instance, by boiling the head in caustic potash. This lobe is figured, minus the hairs and antennae, in Figure 2. The lobe was more pronounced in some individuals than in others, but was present in all specimens observed. Unfortunately some of the specimens had been sectioned before this lobe was discovered, so that it was not possible to determine the extent to which the lobe was present. The reason for the presence of this curious appendage could not be determined. It was at first thought to be a result of the fusing of the tentoria at the forward ends, but subsequent investigation revealed the tentoria in approximately their normal position.

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EXPLANATION AND KEY TO THE FIGURES

Fig. 1. Transverse section of the head of a normal bee, showing the brain and optic lobes and the compound eye.

Fig. 2. Front view of the head of the one-eyed bee showing frontal lobe and single compound eye, antennae and setae removed. (Ommatidia in the region of fusion enlarged.)

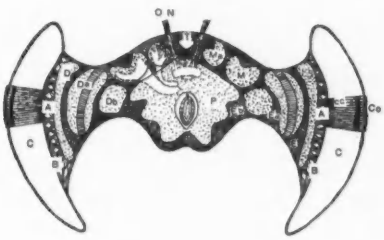
Figs. 3–6. Representative cuts of serial sections of the head of the one-eyed bee progressing from front to rear. Fig. 3 shows the location of the ocelli. The ommatidia in this figure are all in cross-section.

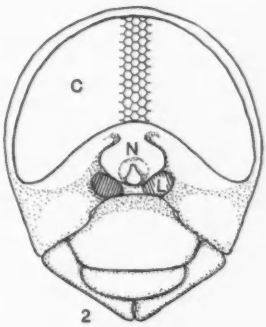
KEY TO THE FIGURES

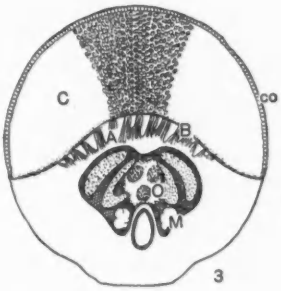
A—Sub-retinal nerve bundles.
B—Basement membrane.
C—Compound eye.
cc—Cone cells of the ommatidia.
co—Corona.
D—Outer chiasma.
Da—Middle chiasma.
Db—Inner chiasma.
E—Outer fibrillar mass.
Ea—Middle fibrillar mass.
Eb—Inner fibrillar mass.
L—Antennal cavity.
M—Outer mushroom body.
Ma—Inner mushroom body.
N—Frontal lobe.
O—Ocellus.
ON—Ocellar nerve.
P—Protocerebral lobe.
S—Separation of basement membranes.
T—Trachea.

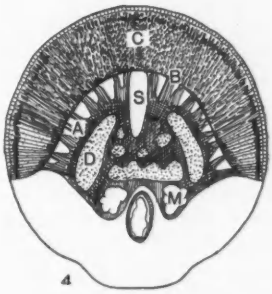
Brain of a One-eyed Bee
Frank E. Miller, Jr.

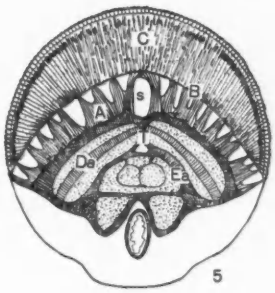
PLATE I

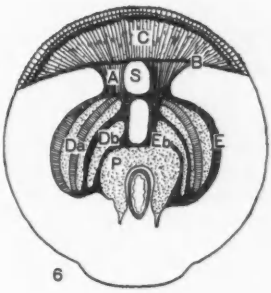












A NEW GENUS—FORCIPATA—AND NINE NEW SPECIES OF TYPHLOCYBINE LEAFHOPPERS CLOSELY ALLIED TO DIKRANEURA

(Cicadellidae: Homoptera)

D. M. DeLong and J. S. Caldwell,
Ohio State University

For several years certain Dikraneura leafhoppers have been commonly collected from grass habitats. These leafhoppers are characterized by having the male plates contiguous at the base and the inner margins convexly rounded outwardly so that the middle portion of the plates are widely separated but they curve together at the apex and are differently shaped from the triangular plates of Dikraneura. This character has been considered as a specific one and all specimens of this type have been placed under the name *Dikraneura fieberi* Loew. Recent study of this material has revealed the fact that this character is generic and several species are undescribed in the material collected in the United States. Furthermore, examination of materials forwarded for study by W. E. China from the British Museum demonstrates that neither *similis* nor *fieberi*, the latter of which Dr. Eger has considered as synonymous with *similis*, occur in North America, if we may judge from material examined in many collections from all parts of the United States and Canada.

The proportional size, shape and apices of the male plates and the appearance of the oedagus in lateral view give excellent characters for diagnosis and have been used to illustrate these species and distinguish them.

Forcipata new genus

The members of this genus differ from the two most closely related genera *Dikraneura* Hardy and *Notus* Fieber by having the male plates more cylindrical and more uniform in width than flat and triangular, and by the plates curving outwardly so as to be widely separated at the middle, but with base and apex contiguous or proximal. Venation more similar to *Dikraneura* but differing by having the first cross vein wanting and the second more distad than the third and the third more distad than the fourth.

The species of the genus usually have a rather bluntly angled head and are yellow in color.[1]

[1]Although submitted for publication in 1934, data concerning material collected in 1935 have been added in all possible cases.

Forcipata loca n. sp.

Resembling *fieberi* in form and appearance but with distinct genitalia. Length, 4 mm.

Vertex rather strongly produced and bluntly angled, more than one third wider between eyes than length at middle, produced half its length before anterior margins of the eyes.

Color: Vertex orange yellow, pronotum and scutellum yellow. Elytra, subhyaline with veins yellow.

Genitalia: Female last ventral segment with central produced lobe rather narrow, notches between this and lateral lobes at base broad and U-shaped. Male plates bearing a sharply pointed spine on inner margins near apex, tips pointed and curving slightly inwardly. Male oedagus in lateral view about the same width throughout except for the pointed apices which are directed dorsally both at the anterior and posterior ends. Between these the central portion is broadly curved dorsally about as far as the apices.

This is the most common North American species of the genus and has previously been designated as *fieberi*. It has been taken as far west as Kansas and South Dakota. The male oedagus was figured by Hartzell as *Empoasca flavescens* in his monograph of that group. (Proc. Dav. Acad. Sci. 30: 1923; Pl. IV, Fig. 23 e.)

Described from a large series of specimens from Ohio, Pennsylvania, New York, Connecticut, Maine, Massachusetts, Vermont, New Hampshire, Virginia, Delaware, Illinois, South Dakota, Kansas and Ontario, Canada. Holotype male from Ohio Pyle, Penna. Allotype female from Kane, Penna., and male and female paratypes in the senior author's collection. Paratype males and females in the Illinois Natural History Survey collection; Snow collection, University of Kansas; the U. S. National Museum collection and the Herbert Osborn collection.

Forcipata magna n. sp.

Resembling *D. fieberi* in general appearance but larger and with distinct genitalia. Length, 3.5 mm.

Vertex of male produced and rounded, twice as wide between eyes as length at middle, produced almost one half its length before anterior margins of eyes. Pronotum more than one half longer than vertex. Female vertex appearing more produced and bluntly angled.

Color: Vertex yellow, tinted on margin with ochraceous. Pronotum and scutellum yellow. Elytra yellowish subhyaline, slightly tinged with green.

Genitalia: Female last ventral segment with median lobe with side margins appearing concavely rounded or angularly indented, apex very narrow, notches between this and lateral lobes, broad. Male plates broad on basal half, narrowed on apical half, a bluntly angled

lobe on inner margin near apex, tip blunt, rounded. Male oedagus in lateral view with a broad basal portion which extends obliquely, apical portion narrow, extending caudally and with pointed apex extending dorsally.

Described from a series of thirty-five specimens collected at Yellowstone Park, Wyoming, July 4, 1930. Male holotype, female allotype and male and female paratypes in collection of senior author.

Forcipata sicula n. sp.

Size and form of *magna* but with distinct genitalia. Length, 3.5 mm.

Vertex blunt, rounded, more than one-third wider between the eyes than length at middle, produced one-half its length before the anterior margins of the eyes.

Color: Vertex pronotum and scutellum dull yellow. Elytra dull greenish subhyaline, veins yellow.

Genitalia: Female last ventral segment with median lobe rather broad at base tapered to almost truncate apex, lateral lobes narrow, about half the length of median lobe, separated from median lobe by rather broad notches. Male plates constricted before apex which is slightly enlarged with a blunt protruding tooth on inner angle and a sharp pointed median tooth on inner margin of apex. Male oedagus curved upward at middle, rather abruptly constricted just before apex which is narrowed and bent sharply so as to extend dorsally.

Described from a series of 37 specimens from Stanley Basin, Idaho; Everett and Copalis, Washington; Eugene and Chehalis, Oregon. Male holotype and male and female paratypes in collection of senior author. Female allotype and male and female paratypes in the collection of Prof. Herbert Osborn. Female paratype in the Snow collection, University of Kansas.

Forcipata triquetra n. sp.

Resembling *fieberi* but with vertex less produced and more blunt and with distinct genitalia. Length, 3 mm.

Vertex not strongly produced, rounded, more than twice as wide between eyes as length at middle, produced one-half its length before anterior margins of the eyes.

Color: Vertex pronotum and scutellum yellowish. Elytra subhyaline with veins yellow.

Genitalia: Female last ventral segment broad, sides of median lobe almost straight, apex broadly rounded, lateral lobes very narrow produced about half the length of median lobe. Male plates slightly constricted just before apices which are slightly enlarged and rounded on apex, their inner margins each bearing a short sharp-pointed tooth at about the middle of the inner face and a shorter one also sharp-pointed at the base of inner face. Male oedagus in lateral view elongate, triangular. Base rather broad, gradually tapering to acutely pointed apex which is curved and directed a little dorsally.

Described from a series of 20 male and female specimens from Dickinson Co., Kansas; Brookings, South Dakota; Conifer, New York; Delphos, Kansas; Volo, Dolson and Vienna, Illinois; Lincoln, Nebraska; West Point, Nebraska; Douglas Co., Kansas, and Missouri Valley, Iowa. Holotype male, allotype female and male and female paratypes in collection of senior author. Male and female paratypes in collection of Prof. Herbert Osborn and the Snow collection, University of Kansas, and three female paratypes in the Illinois Natural History Survey collection, Urbana, Illinois. Female paratype in U. S. National Museum Collection.

Forcipata ohioensis n. sp.

A narrow species resembling *fieberi* but with distinct genitalia. Length, 3 mm.

Vertex of male bluntly angled twice as wide between eyes as length at middle, two-thirds of its length produced before anterior margins of the eyes. Anterior margin of pronotum strongly convexly produced.

Color: Vertex, pronotum and scutellum yellowish. Elytra dull greenish subhyaline, veins yellow, conspicuous.

Genitalia: Female last ventral segment with central produced lobe narrow, rounded at apex, side lobes produced two-thirds the length of central lobe. Male plates broader at base, rather strongly curved inwardly at apices which are blunt and rounded without an enlargement or protruding spine on inner margin. Male oedagus in lateral view triangular, broad at base, rapidly tapering to slender apical portion which is strongly curved and produced dorsally.

Described from a series of 29 male and female specimens collected at Circleville, Ohio, June 3, 1934, by the junior author; one male specimen collected at Loda, Illinois, November 3, 1931, by Dr. H. H. Ross, and 15 male and female specimens collected at Shawneetown, Albion, Vienna and Putnum, Illinois, in 1935, by Dr. H. H. Ross and the senior author. Male holotype, female allotype and male and female paratypes in the collection of the senior author. Male and female paratypes in the Illinois Natural History Survey collection.

Forcipata ancantha n. sp.

A minute species with strongly produced vertex, resembling *ohioensis* but with distinct genitalia. Length, 3 mm.

Vertex strongly produced and rather sharply angled, one-third wider between eyes than length at middle, produced two-thirds its length before anterior margins of the eyes.

Color: Yellow tinged with orange. Basal half of elytra yellow, apical half subhyaline with veins yellow.

Genitalia: Female last ventral segment with median lobe narrowed to rather narrow, rounded apex. Male plates only slightly enlarged on inner margin before apex, apices narrowed and directed inwardly. Male oedagus in lateral view appearing broad on basal half, apical half narrowed, directed ventrally and caudally, tip curved and produced dorsally.

Described from a series of fifty male and female specimens collected from small grasses at Castle Rock, Oregon, Illinois, by Dr. H. H. Ross and the senior author June 30, 1935. These occurred in a heath habitat. Holotype male, allotype female and male, and female paratypes in Illinois Natural History Survey collection. Male and female paratypes in the collection of the senior author.

Forcipata acclina n. sp.

Form and appearance of *ohioensis* but with distinct genitalia. Length, 3.2 mm.

Vertex strongly produced and bluntly angled, almost two-thirds as long at middle as width between eyes, produced almost two-thirds its length before anterior margins of the eyes.

Color: Yellowish, apex of vertex tinged with orange, pronotum and scutellum yellowish. Elytra subhyaline, veins yellow.

Genitalia: Female last ventral segment short and broad, broadly rounded, lateral lobes scarcely produced beyond notched base of central lobe. Male plates rather abruptly bent and curved inwardly at about half their length, broadened at apex and curved so as to form a concaved face between a pointed tooth at anterior and posterior extremities. Male oedagus long, bluntly pointed at base, curved upward at middle, constricted near apex then bent upwardly at right angles and produced dorsally forming a rather long spine-like apex.

Described from a series of 15 specimens from Taylor's Falls, Minn.; Kane, Pa.; Enterline, Pa., and Kreamer, Pa., collected by J. G. Sanders and the senior author; Conifer, N. Y.; Cranberry Lake, N. Y.; Brookings, S. D. and Fargo, N. D., collected by Prof. Herbert Osborn; Windsor, Vt., and Glen, N. Y., collected by Dr. R. H. Beamer. Male holotype and male and female paratypes in the collection of the senior author. Female allotype and male and female paratype in the Osborn collection and female paratypes in the Snow collection, University of Kansas.

Forcipata calipera n. sp.

A small species resembling *ohioensis* in general appearance but with distinct genitalia. Length, 3.2 mm.

Vertex strongly produced and rounded, one-third wider between eyes than length at middle, produced one-half its length before anterior margins of the eyes.

Color: Vertex, pronotum and scutellum orange yellow. Elytra with basal half rather opaque and orange yellow in color, apical half hyaline, only the veins yellowish.

Genitalia: Female last ventral segment with median lobe narrow, apex rounded, lateral lobes about two-thirds as long as median lobe. Male plates with a rounded enlargement on inner margins about middle, apical third strongly curved inwardly and extending at almost right angles to basal portion and almost touching at median line. Male oedagus in lateral view a little wider at middle, apices tapered and sharp pointed, curved twice so that apical and basal portions and central curved lobe extend dorsally.

This species can easily be distinguished by the strongly curved male plates.

Described from a large series of specimens from Kane, Penna., 8-22-19; Enterline, Penna., 7-4-20; Kreamer, Penna, 7-26-18; North Bloomfield, Penna., 7-16-20; Pt. Trevoiton, Penna., 7-26-18; Richfield, Penna., 7-26-18, and Taylor Falls, Minn., 8-16-18, all collected by J. G. Sanders and the senior author. Also one specimen from Salem, N. Y., August 15, 1904, collected by Prof. Herbert Osborn, and one from Cranberry Lake, N. Y., August 5, 1917, by Dr. C. J. Drake. Male holotype, female allotype and male and female paratypes in senior author's collection; female paratypes in collection of Prof. Herbert Osborn.

Forcipata ortha n. sp.

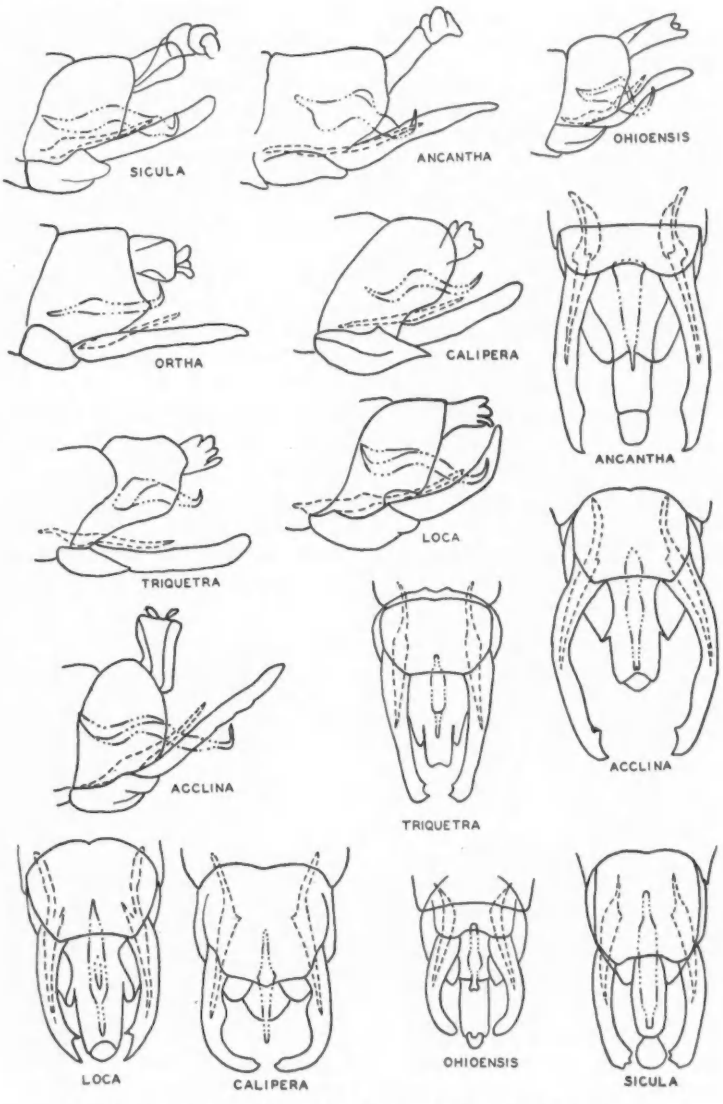
Resembling *calipera* but with vertex more produced and sharply angled and with distinct genitalia. Length, 3.5 mm.

Vertex bluntly angularly produced, more than one-third wider between eyes than length at middle, produced about two-thirds its length before anterior margins of the eyes.

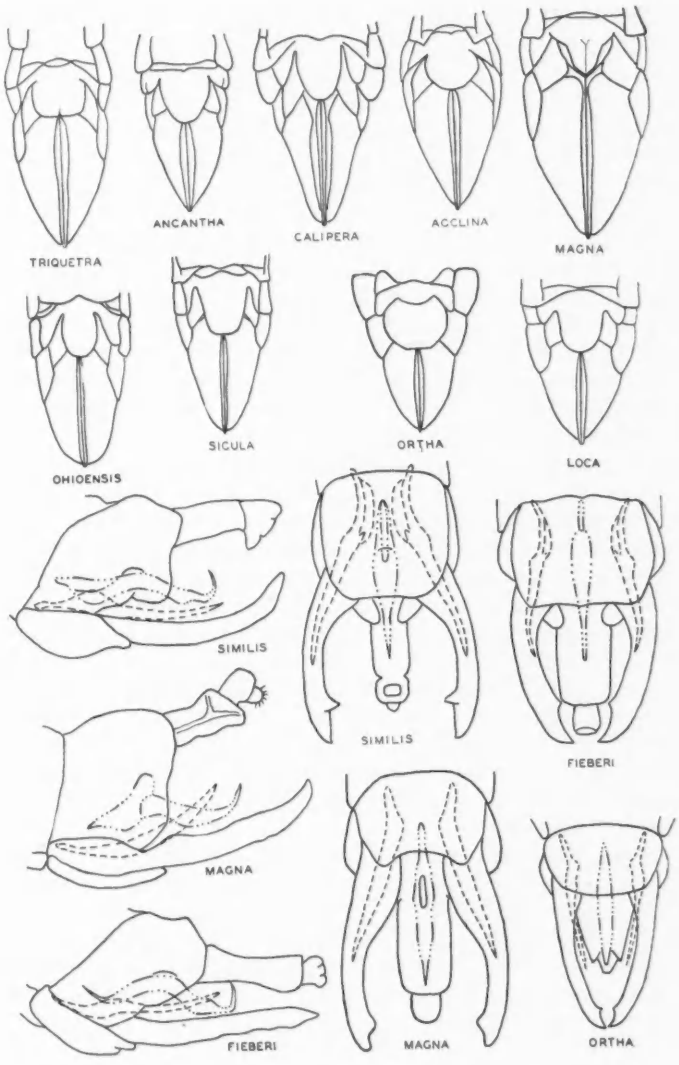
Color: Vertex pronotum and scutellum dirty yellowish. Elytra dull green tinged with yellow on claval area, remainder hyaline with yellow veins. Apical portion smoky.

Genitalia: Female last ventral segment with median lobe broad, rounded to blunt apex. Side lobes very small, almost wanting. Male plates almost uniform in width with a sharp pointed spur just before apex on inner margin. Apex sharp pointed. Male oedagus in lateral view almost straight to apex which is sharply upturned and tapered to pointed tip. Basal end narrower, tapered, caudal to which the oedagus is slightly enlarged dorsally.

Described from a series of 14 specimens from Kane, Richfield, Harrisburg and Pt. Trevoiton, Penna., collected by J. G. Sanders and the senior author, and specimens from Maine, collected by Prof. Herbert Osborn. Holotype male (Kane, Penna.) allotype female (Kane, Penna.) and male and female paratypes in the collection of the senior author. Female paratypes (Maine) in the Osborn collection.



Forcipata new genus. Lateral and ventral views of male genitalia.



Forcipata **new genus. Ventral view of female genitalia (top); ventral and lateral views of male genitalia (bottom).**

THE RAPID SPREAD OF AN EUROPEAN STAPHYLINID IN NORTH AMERICA

(Coleoptera, Staphylinidae)

RALPH VORIS,
Southwest Missouri State Teachers College,
Springfield, Missouri

Philonthus cruentatus (Gmel.) was first reported in North America by Notman in 1924 from New York State and at the present time is known to occur in the east and middle west in most of the states north of Tennessee and westward into California. However, our last collections in the south were made in 1927 and it is possible that the species now ranges farther south. By its rapid distribution and abundance in many localities, it would seem that this will become one of our most common species of staphylinids.

From the information at hand it appears that the species was introduced into the United States near the beginning of this century. It was not included in Blatchley's Coleoptera of Indiana published in 1910, which would lead us to believe that it was not present in any great numbers at that time. If we allow him five years for working up his material that would set the Indiana date as 1905. Allowing for migration, we can set the probable date of introduction about 1900. Dr. M. H. Hatch found the species in 1917 in Michigan, and in 1924 it was very abundant in Indiana. How soon the species reached the Pacific coast is not known, but the first collection was made by G. S. Myers in 1928 and it was found to be quite common there in 1931.

Fortunately this importation is a beneficial one and should not be viewed with alarm. Although *P. cruentatus* may be found in or near decaying fungi or in carrion, its normal habitat is dung and barn-yard refuse. The feeding behavior is not to be confused with the habitat, however, for it is a predacious insect. A few minutes observation at a dung heap will convince one that this beetle is a veritable dragon, always ready to pounce on unsuspecting flies. The larvae are to be found in the same sort of habitat as the adults, but never in the very fresh material. The feeding behavior of the larvae is the same

as that of the adult. Pupation occurs near the bottom of the dung heap.

From its habitat and feeding behavior it is probable that this beetle was introduced from Europe in the refuse from cattle boats. The bedding and dung is treated with chloride of lime and brought ashore to be stacked up outside the city limits. It is quite probable that in some cases the chloride of lime treatment was delayed until after the refuse was brought ashore (acc. J. L. Webb *in litt.*, Assoc. Entomologist, Bureau of Entomology and Plant Quarantine, U. S. D. A.). The use of refuse from cattle cars and stock pens as fertilizer also provides an explanation for the mechanical distribution of the species after it had arrived in the United States.

The rapid spread of *P. cruentatus* is further understandable because the adult is a strong flier and is not dependent on weather conditions for its distribution. It is not restricted by specialized feeding behavior and there is no definite seasonal life cycle. The eggs are deposited singly during the warmer months of the year in the material in which the adult searches for food. Young larvae, mature larvae, pupae, and adults may be found hibernating in the same dung heap, although in summer the adults are more numerous in the fresher material and the larvae and pupae are more numerous in the older dung heaps. Because of this life-history an unfavorable season retards the spread of the species for a few months at the most, while if the species had a yearly cycle it would be retarded for an entire year. In fact all its behavior is favorable to its rapid distribution.

The material available for study consists of 28 specimens from 12 localities in Europe and 656 specimens from North America from 108 localities.

Material has been examined from the following localities and carefully compared with material from central Europe.

New York: Rochester (R. L. Post Coll.), Onondago Co. (M. H. Hatch Coll.).
Michigan: Washtenaw Co. (M. H. Hatch Coll.), Houghton Co. (M. H. Hatch Coll.), Grand Haven, White Cloud, Douglas Lake, Charlevoix, Boyne City, Gwinn, Manton.
Indiana: Troy, Dale, French Lick, Washington, Lafayette, Pine Village, Elkhart, Freedom, Lapel, Indiana Dunes State Park, Pendleton, Kern, Tefft, Noblesville, Fowler, Bloomington, Fishers, Bass Lake, Winona Lake, Charlestown.
Kentucky: Paducah, Pineville.
Tennessee: Maynardsville.
Illinois: Lake Co. (B. Benesh Coll.), Olney, Bloomfield.
Wisconsin: Stanley, Shawno, Hurley, Spider, Wittenberg, Trout Lake.
Minnesota: Cokato, Larsmont, Int'l Falls, Roosevelt, Orr, Hallock.
Manitoba: Brandon, Morris.

North Dakota: Minot, Washburn, Dickinson.
South Dakota: Yankton, Deadwood, Clear Lake, Black Hills State Park, Bellefourche.
Nebraska: Pierce, Chadron, Crawford, Beatrice.
Missouri: North Kansas City.
Kansas: Winfield.
Colorado: Denver, Durango, Pagosa Springs, Aspen, Lewis, Estes Park, Mesa Verde Nat'l. Park, Crowe, Portland, Colona, Glenwood Springs, Ojo, Palmer Lake.
Wyoming: Cheyenne, Laramie, Bosler, Hat Creek.
Utah: Kaysville, Kamas, Cedar City, Pine Valley, Monticello, Lasal, Bryce Canyon, Eureka, Marysvale.
Nevada: Reno.
California: San Mateo Co. (G. S. Myers Coll.), Lake Tahoe, Bishop, Palo Alto, Folsom City, Mono Lake, Yosemite Nat'l. Park, Usona, Little Lake, Bigpine, Dixon.

All material was collected by the author unless otherwise noted and is in the authors collection.

Dr. M. H. Hatch has furnished the following locality records from material in his collection.

Michigan: Berrien Co.
Ontario: Toronto, Gull Lake (Muskoka Co.), White Lake.
California: Fairfax (Marin Co.).
Idaho: Waha.
Oregon: Blue Mts. (5000 ft.), Cottage Grove, McKenzie Pass.
Washington: Seattle, King Co., (Evans Creek), Blue Mts. (5000 ft.), Mt. Rainier (Slippery Creek and Paradise Park), Stehekin, Palouse, Pullman, Spokane, Hooper.

OUR INSECT FRIENDS AND FOES AND SPIDERS, edited by GILBERT GROSVENOR. pp. 1-252; 100 text figures, 102 plates, 64 of which are in colors. Published by The National Geographic Society, Washington, D. C. $2.50.

This lovely volume is a republication in solid linen binding of material which has appeared from time to time in article form in "The National Geographic Magazine." Whether a straight reprint or not, it does not matter and we cannot check, as our "National Geographics" have been scattered from cellar to garret by the Editor's small son and daughter, not to mention the wife and maids. The National Geographic Magazine is the most popular journal in our household. This volume on insects and spiders is a condensed and intensified publication of the same type.

The contents are as follows: Chapter I. Exploring the Wonders of the Insect World, by W. J. Showalter; II. Insect Rivals of the Rainbow, Showalter; III. Man's Ally, the Honeybee, J. I. Hambleton; IV. Stalking Ants, Savage and Civilized, W. M. Mann; V. Living Casks of Honey, Jennie E. Harris; VI. Familiar Moths and Butterflies, W. J. Showalter; VII. Where Our Moths and Butterflies Roam, Showalter; VIII. Afield with the Spiders, H. E. Ewing; IX. California Trapdoor Spider, Lee Passmore.

The many excellent colored drawings of the activities of insects are by Hashime Murayama. Besides these are the many colored plates of the most strikingly colored insects that could be found in the National Museum collections. The legends of the colored plates give the scientific names and references to any mention in the text.

Our best indication of the value of this remarkable volume is that every trained entomologist who has leaved through our copy has immediately taken out his pencil to note the title, price and place of publication. Also each appears to avoid looking one squarely in the eye when he states that he is getting a copy for a friend interested in insects. It is without question the finest popular work on insects of which we know. Every entomologist should have a copy in that first line of defense against the visitor who wishes to know about insects without the toil of chasing them with a net and running them through keys.—C. H. K.

THE METASTERNAL GLANDS OF THE ANT, MYRMICA RUBRA, WITH SPECIAL REFERENCE TO THE GOLGI BODIES AND THE INTRACELLULAR CANALICULI

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Golgi bodies and intracellular canaliculi have been observed in cells having secretory function (Beams & King, '32, a, b, '33). The purpose of this paper is to report the presence of these structures in the metasternal glands of ants. These glands are paired organs located in the posterior region of the thorax and open to the outside through orifices located near the pleural-sternal margins of the metathorax. They were observed first by Meinert (1860) and later Lubbock (1879), Janet (1898) and Emery directed some attention to their gross structure. These glands are peculiar to the ants and are present in all of the castes. The function of these glands is not known although Janet suggested that they might be involved in the production of the nest odor which enables an ant to recognize members of its own colony.

MATERIAL AND METHODS

Myrmica rubra laevinodis Nyl., one of the Myrimicine ants, was selected for study. Although it is a small form (4 mm.) it is suitable for this purpose since it possesses well developed metasternal glands. The thorax of this form was placed in a drop of normal saline under a dissecting microscope and a longitudinal incision was made exposing a gland in each part. The glands then were dissected away from the chitinous exoskeleton and fixed or studied in the living condition.

The rapid chrome-silver process of Golgi was used for the demonstration of the intracellular canaliculi. This method also brought out disc-like structures with dark rims and clear centers suggestive of the typical insect Golgi bodies. In addition, the Kolatchef method was applied to these glands with the result that the Golgi bodies and the intracellular canaliculi were demonstrated. Although mitochondria were not observed in these cells, the Champy-Kull method brought out the intracellular canaliculi very clearly.

DESCRIPTION

A single metasternal gland may be divided into two general regions: (1) an accessory structure formed by the invagination of the chitinous

metapleuron (Fig. 2A) and (2) the gland proper consisting of a number of unicellular glands (Fig. 2B) forming a cap over and connecting singly to the apex of the accessory structure (Fig. 2E) by intercellular canaliculi (Fig. 2G).

The limits of the accessory structure are visible through the exoskeleton of the thorax.

In the worker and the female it is large and conspicuous, but in the male it is reduced in size (Fig. 1). In all forms the accessory structure projects forward and dorsally down beneath the exoskeleton towards the propodeal spiracle and converges slightly toward the mid-line of the body. The orifice of the accessory structure (Fig. 2C) is located at the lower edge of the metapleuron and is provided with hairs which project in a horizontal plane towards the center of the opening. Within the accessory structure, hairs are present in the apical region and on one portion on the lateral face. These are clearly visible through the exoskeleton (Fig. 2 D).

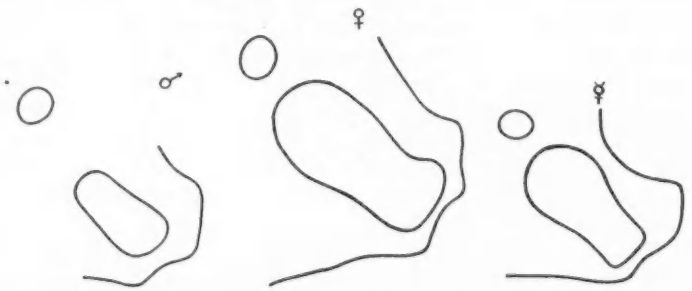

FIG. 1. Limits of the accessory structure of the metasternal glands in male, female and worker.

The hairs from the apical region converge toward the center of the lateral portion of the accessory structure and then point ventrally toward the orifice. Additional hairs arise in two definite lines down toward the orifice. The final arrangement is such that there is two distinct lines of hairs bordering on a thin narrow portion which is entirely devoid of hairs (Fig. 2D). Possibly the hairs function in the nature of a capillary tube directing the secretion products of the gland cells to the orifice of the accessory structure. At the apex of the accessory structure there is a perforated sieve plate (Fig. 2E) which is subdivided into many smaller regions by chitinous thickenings. Each opening is in the center of a papilla (Fig. 2F) which gives to the inner surface a roughened appearance.

Surrounding the apex of the accessory structure there are about 100 unicellular gland cells which compose the tissue of the organs. The cells are pyramidal in form and are approximately twice as long as wide (10 μ x 21 μ). The spherical nucleus is about 6 μ in diameter and is eccentrically located. The basal portions of the cells are directed

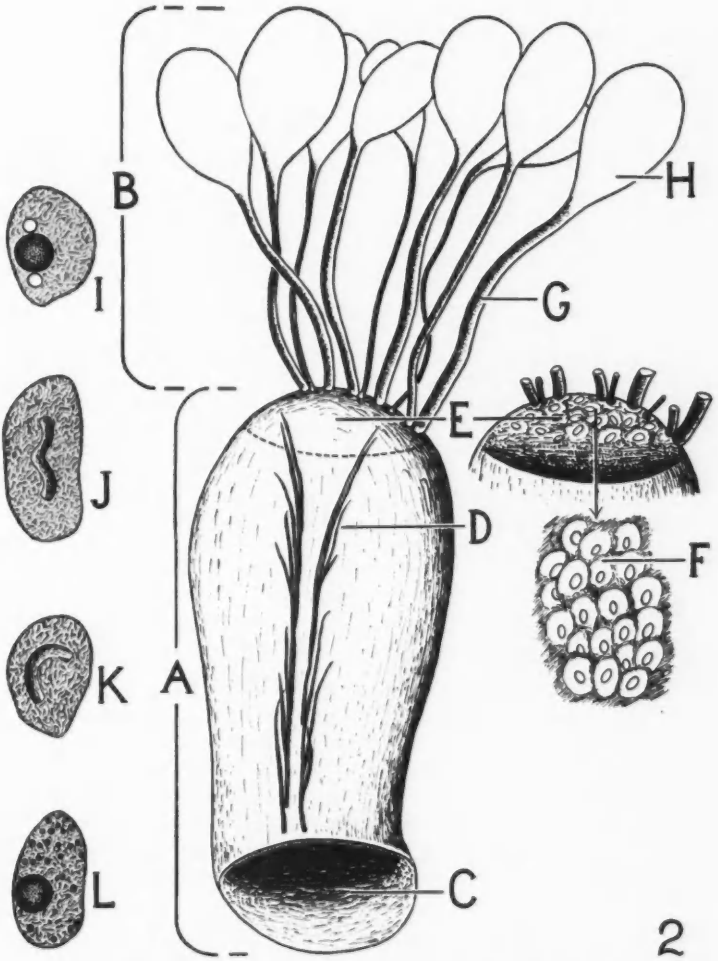

FIG. 2. Reconstruction of a metasternal gland.

A. Accessory structure.
B. Gland proper.
C. Orifice of accessory structure.
D. Lateral hairs of accessory structure.
E. Apex of accessory structure.
F. Enlarged portion of sieve plate showing papillae.
G. Intercellular canaliculus.
H. Unicellular gland.
I–K. Sections showing intracellular canaliculi.
L. Section showing Golgi bodies.

away from the apex of the accessory structure, with the tapered portions being directed toward and connected with the apical sieve plate by intercellular canaliculi (Fig. 2G). All of these efferent tubules are the same length, hence all of the cells of the gland are equidistant from the apex of the accessory structure.

The intercellular canaliculi enter the cells as intracellular elements, coil slightly toward the nucleus and end blindly in the cytoplasm at the distal portion of the cell (Figs. 2 I-J-K). The canaliculi are about 1.4 μ in diameter and have the same regular shape and size both inside and outside the cells. They do not collapse during fixation and it is possible that they may be chitinous in nature. The intracellular canaliculi are demonstrated very clearly by osmic-acid or chrome-silver methods.

Secretion globules when present are usually in the distal portion of the cell.

Golgi material within the gland cells can be demonstrated either with osmic-acid or silver impregnation methods. These Golgi bodies are of the typical insect form (Fig. 2L) similar to those found in the honey bee (Beams and King, '33). They are distributed evenly throughout the cytoplasm with no indication of polarity. In this study glands were removed at different times of the day and from ants of different ages, yet no noticeable differences could be detected in the amount of or the distribution of the Golgi material.

CONCLUSIONS

1. A single metasternal gland may be divided into two general regions: (1) an accessory structure formed by an invagination of the chitinous metapleuron and (2) the gland proper consisting of a number of unicellular glands forming a cap over and connecting singly to the apex of the accessory structure by intercellular canaliculi.

2. The intercellular canaliculus as it enters the cell becomes continuous with an intracellular canaliculus, the latter ends blindly in the cytoplasm at the distal portion of the cell.

3. Golgi bodies of the typical insect form are present in all of the cells.

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NEARCTIC SPIDERS OF THE GENUS WUBANA

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The genus *Wubana* represents a distinct group of spiders in the Micryphantidae. Only two species have been heretofore known. Four new species from the western United States brings the present number up to six. Other species will undoubtedly be added in the future.

Genus **Wubana** Chamberlin, 1919

Legs long and tapering. Upper claws with a very large blunt tooth, which makes the claw appear bifurcate. The male, in the adult stage, has a cephalic horn or protuberance, which rises back of the posterior median eyes, or between them, and which bears a tuft or crest of long, curved, overlapping hairs. This cephalic horn and crest of hairs does not develop until the last moult. Both eye rows straight in the female, but the posterior row may be slightly recurved in the male. Epigynum simple, protruding beyond the surface of the abdomen, with openings concealed. Palpus distinct in the structure of the tibia, paracymbium, embolus, and "conductor." The embolus makes one single large loop.

The spiders of this genus, in the field, have the appearance of true Linyphiids more than of typical Micryphantids. However, the structural characters correspond to those of the latter group.

Genotype: Wubana drassoides (Emerton).

The genotype may be regarded as typical in most respects for the genus. Therefore, it is described below in considerable detail, while the other species are described only as they differ from the typical.

The species may be separated by the following key:

KEY TO SPECIES

MALES

A. With a cephalic horn rising back of the P. M. eyes.
  B. Elevation of the horn above the P. M. eyes about the same height as the width of the clypeus (see Fig. 35)..... **suprema**
  B'. Height of horn decidedly less than width of clypeus.
    C. Front of horn situated a full eye diameter or more back of the P. M. eyes (see Fig. 40)..... **pacifica**
    C'. Front of horn situated less than an eye diameter back of the P. M. eyes.
      D. Conductor of palpus with a ventral angle or process near middle of length as seen in outline from ectal view (see Figs. 19–21)... **drassoides**

D'. Conductor with ventral outline gradually curved along middle as seen from ectal view.
E. Paracymbium large, with caudal process stout at end, and extending nearly to base of tibia (see Fig. 27).....**utahana**
E'. Paracymbium smaller, with caudal process narrow at tip and not extending nearly to base of tibia (see Fig. 32).....**ornata**
A'. Without a distinct horn, but with a conical elevation on the head rising between the P. M. eyes (see Fig. 45).....**atypica**

FEMALES

A. Abdomen of nearly a uniform color for the most part above, exclusive of the light band or spot above the spinnerets.
B. Abdomen light yellowish gray to medium gray without markings, or with markings indistinct (see Fig. 46); length 3 mm. or more.....**atypica**
B'. Abdomen mostly black with a light transverse band above spinnerets (see Fig. 41); length about 2.4 mm.....**pacifica**
B''. Abdomen dark gray above with sides lighter; pattern above indistinct (see Fig. 36); length over 2.5 mm. (Characters taken from male), **suprema**
A'. Abdomen with a distinct pattern of markings above.
B. Epigynum protruding far out from abdomen; tip with a small notch (see Figs. 22–23).....**drassoides**
B'. Epigynum not protruding so far out from abdomen.
C. Tip of epigynum bearing two slender white processes (see Fig. 34), **ornata**
C'. Tip of epigynum blunt, without such processes (see Figs. 28–29)..**utahana**

Wubana drassoides (Emerton).

(Pl. I, Figs. 1–3; Pl. II, Figs. 4–14; Pl. III, Figs. 15–24)

Bolyphantes drassoides Emerton, *Trans. Connecticut Acad. Sci.*, VI: 72, pl. 23, f. 5, 1882.
Nematogmus drassoides Banks, *Bull. U. S. Nat. Mus.*, No. 72: 28. 1910.
Sphecozone drassoides Petrunkevitch, Catalog American Spiders, p. 270. 1911.
Wubana drassoides Chamberlin, *Ann. Ent. Soc. America*, 12: 252. 1919.
Wubana retrahens Chamberlin, ibid., p. 253, pl. 18 f. 10. 1919.
Wubana drassoides Bishop and Crosby, *Journ. New York Ent. Soc.*, 42: 215, pl. 14, ff. 1, 4, 8, 9. 1934.

Color: Carapace orange or light brownish yellow, with the horn and a shield-shaped area back of the horn lighter; the interocular area more or less filled in with black. Chelicerae orange. Endites, labium, and sternum yellowish—the labium somewhat dusky, and the sternum with a narrow margin along the sides and the point behind dusky. The legs and palpi pale yellow to yellowish orange—the cymbium and palpal organs of male darker.

Abdomen dark gray or blackish above with a pattern of light gray or whitish markings, consisting of: two pairs of large spots on basal half, followed behind by three transverse, slightly chevron-shaped bars; back of these is a broad light band which extends across the dorsum just above the spinnerets, then extends forward along the lower sides to the base. This band just above the spinnerets contains a large spot of white in the center. Spinnerets encircled by a dark ring. Venter dark gray, becoming more or less faded to a light gray, especially in the middle behind. The dark gray color of the venter may extend on to the epigastric region, but more often this region is pale yellowish, narrowly surrounded with dark gray. Epigastric plates, spinnerets, and postabdomen light yellowish.

The abdomen of light colored specimens has the dark gray areas faded to a lighter gray, and has the light areas more extensive and often running together.

Structure: Female—Carapace longer than wide; margin of base concave, sides of thoracic part rounded, cervical indentations slight, margin of clypeus rounded. Cervical grooves and median furrow lacking. Clypeus nearly vertical; width about three diameters of anterior median eyes. Carapace of average height; as seen from the side, top extends back from the eyes at about the same level for over half the length, then descends steeply to the base.

The anterior median eyes dark and slightly smaller than the others, which are pearly white and about equal in size; the ratio of size being 9:11. Posterior row straight; median eyes about three-fourths of a diameter apart, and about a radius from the side eyes. Anterior row straight; the median eyes less than a radius from the side eyes, and slightly nearer to each other. Anterior median eyes about one of their diameters from the posterior median eyes; lateral eyes contiguous. Median ocular area about as wide as long, and wider behind than in front.

Chelicerae vertical, and of the usual shape. Stridulating file fine. Fang simple. Furrow with four teeth above, separated from each other, and four teeth below placed close together.

Sternum large, shield-shaped; slightly longer than wide. Anterior margin slightly convex; anterior corners square; sides in general rounded, with slight angulations between the legs; posterior tip starting to become attenuate, then abruptly truncate, separating the hind coxae by nearly a diameter of one of them.

Labium short and wide, the width being more than twice the length; rounded in front. Endites stout, convergent around labium.

Palpus slender, reaching to about the distal end of femur I. Tibia and tarsus with a number of heavy setae.

Legs long and tapering; order of length: IV, I, II, III. Without spines, but with several enlarged setae—one at the tip of the patella, two on midline of tibia above, and one or two at distal end of femur below. Paired claws with a very large, blunt tooth below, and two or three small teeth; median claw with one tooth.

Abdomen oval; length one and one-half times the width or longer; only slightly wider than high. Base rounded, overlapping cephalothorax only slightly. Spinnerets at the apex below; of the usual shape. Epigynum externally simple; protruding beyond the surface of the abdomen; without openings above; two large sacs showing through the integument. Margin of furrow extending downward and backward into a blunt point, which is notched in the center in this species.

Male—Carapace oval, a little longer than wide; straight across base with corners rounded; sides rounded; becoming narrower anteriorly, with margin rounded across front; without cervical indentations. Clypeus nearly vertical, width more than three times the diameter of an anterior median eye. A short, blunt cephalic horn arises just back of the posterior median eyes, extending upward and forward. This

horn bears a crest of long, stout, overlapping hairs, which extend over the median ocular area and beyond the front of the carapace; the foremost of these hairs is much stouter than the others. Back of the horn, the profile levels off to beyond the middle, then declines steeply to the base. Carapace, aside from the horn, of average height.

The eye arrangements slightly distorted due to the presence of the cephalic horn. The posterior row slightly recurved; the median eyes nearly a diameter apart, and a scant radius from the side eyes. Eyes otherwise as in female. The median ocular area wider than long, and contains a pair of stout, vertical setae.

Chelicerae, endites, labium and sternum much as in female, with the chelicerae tending to be more slender, the endites more bulged ectally, and the sternum slightly wider in proportion. Legs similar to those of female, but with metatarsi and tarsi proportionately slightly longer.

Palpus of a distinctive type. Femur and patella unmodified. Tibia with a long, thick process above, which curves ectally and lies alongside of the base of the cymbium. Cymbium essentially typical for the family. Paracymbium large, with a long caudal process and two sharp processes on distal part. Embolus slender, arising from a small pouch on the mesal side near the anterior end, then making a large loop back along mesal side, across base, and forward along the ectal side to terminate near the place of origin; supported by a heavy conductor-like structure for more than the distal half of its length.

Abdomen as in female.

MEASUREMENTS:

	Female	*Male*
Length	2.20 mm.	2.13 mm.
Carapace:		
Length	.93	.93
Width	.73	.75
Abdomen:		
Length	1.27	1.20
Width	.73	.73
Chelicerae	.33	.33

LEGS	*Female*					*Male*				
	I	II	III	IV	Palpus	I	II	III	IV	Palpus
Coxa	.28	.26	.22	.26	.....	.26	.25	.26	.27	.....
Trochanter	.10	.10	.08	.10	.07	.10	.09	.08	.09	.09
Femur	.93	.87	.73	1.00	.27	.90	.87	.78	1.00	.33
Patella	.28	.27	.26	.25	.13	.28	.27	.24	.32	.17
Tibia	.83	.77	.60	.93	.18	.83	.73	.60	.93	.....
Metatarsus	.73	.66	.60	.83	.....	.79	.71	.63	.93	.....
Tarsus	.52	.45	.37	.47	.32	.55	.51	.43	.53	.....
Total	3.67	3.38	2.86	3.84	0.97	3.71	3.43	3.02	4.07	1.04

Type locality: Mt. Carmel, Hamden, Connecticut. Male holotype. (In collection of M. C. Z. at Harvard.)

Other localities: California — Laguna Beach; Palo Alto; Montrose; Berkeley. *Arizona*—Grand Canyon, males and females (R. V. Chamberlin, collector). *Utah*—Lasal Mts.; Fillmore; Uintah Mts.; Chalk Creek (R. V. Chamberlin, collector).

The following localities are also recorded by Bishop and Crosby (1934): *District of Columbia. North Carolina*—Minehole Gap; top of Blue Ridge. *Maryland*—Cabin John.

This is a widespread species and specimens from different localities show some variation. These differences may be of varietal importance, but this cannot be adequately determined from the limited number of specimens at hand.

Wubana retrahens Chamberlin was based on a male which has not completed its last moult, though the palpal organs show clearly through the integument. The caphalic horn has not yet developed.

Wubana utahana Chamberlin and Ivie, new species
(Pl. III, Figs. 25-29)

Color as in *Wubana drassoides* (Emerton).

Structure: Female—Posterior median eyes nearly a diameter apart, scarcely a radius from the side eyes. Median ocular area slightly wider than long. Epigynum protruding much less than in *drassoides*.

Male—Structure the same as in *drassoides*, except for the palpus, where the paracymbium and conductor show distinct differences.

MEASUREMENTS:

	Female	*Male*
Length	2.90 mm.	2.40 mm.
Carapace:		
Length	1.15	1.03
Width	.86	.82
Tibia-patella:		
I	1.40	1.33
IV	1.52	1.42

Type locality: Mirror Lake, Uintah Mts., Utah. Male holotype, female allotype. (W. Ivie, collector, Sept. 22, 1932.)

Other localities: Smith and Morehouse Canyon and Chalk Creek Canyon, Uintah Mts., Utah; Fish Lake, Utah.

Found mainly under rocks and logs near wooded streams.

Wubana ornata Chamberlin and Ivie, new species
(Pl. IV, Figs. 30-34)

Color typical, with carapace of male darker in front, and with a broad shield-shaped mark back of the horn of a lighter color. Abdomen darker than typical, with color markings very distinct.

Cepahlic horn small. Size below average. Palpus and epigynum as figured.

Measurements:	*Female*	*Male*
Length	2.20 mm.	2.00 mm.
Carapace:		
Length	.93	.90
Width	.72	.72
Tibia-patella:		
I	1.21	1.17
IV	1.26	1.21

Type locality: Laguna Beach, California. Male holotype. (W. Ivie, collector, Dec. 28, 1932.)

Other locality: Montrose, California. Female allotype. (W. Ivie, collector, Dec. 31, 1932.)

Wubana suprema Chamberlin and Ivie, new species

(Pl. IV, Figs. 35–39)

Color: Carapace light dusky orange, with the cephalic horn and the median cephalic area just back of the horn light yellowish. Interocular area not black. Abdomen dark gray above, without the typical light markings, except the broad light band just above the spinnerets, which contains the usual white spot. Sides and venter for the most part pale gray. Spinnerets encircled with dark gray. Epigastric area encircled with darker gray. Color otherwise typical.

Structure: Male—Cephalic horn larger and taller than typical. Bristles of median ocular area typical. Eye arrangement typical. Palpus in general of the usual form, with specific variations. Structure otherwise essentially typical. Size above the average. Body stout.

Measurements:	*Male*
Length	2.50 mm.
Carapace:	
Length	1.13
Width	.90
Tibia-patella:	
I	1.50
II	1.60

Type locality: Weed, near Mt. Shasta, California. Male holotype. (W. Ivie, collector, Sept. 8, 1935.) Found under a rotten pine log near a stream.

Wubana pacifica (Banks)

(Pl. V, Figs. 40–44)

Bolyphantes pacificus Banks, Trans. American Ent. Soc., 23: 69. 1893. (Male, not female.)

Nematogmus pacificus Banks, Bull. U. S. Nat. Mus., No. 72, 1910, p. 28.

Nematogmus pacificus Petrunkevitch, Catalog American Spiders, p. 260, 1911.

Wubana pacifica Chamberlin, Ann. Ent. Soc. America, 12: 252. 1919.

Wubana pacifica Bishop and Crosby, *Journ. New York Ent. Soc.*, 42: 217, pl. 14, ff. 2, 3, 5, 6, 7, 10 (in part).

Color typical, except for the abdomen, which is black or dark gray, with the usual broad whitish transverse band above the spinnerets containing the typical white spot; the sides often lighter gray. Interocular area not black, but each eye surrounded by black. Immature and light colored specimens are more typical in the color of the abdomen.

The structure of the male varies from the typical in the following details: Cephalic horn more vertical, and situated back of the posterior eye row by a full diameter of a posterior median eye. Anterior median eyes projecting farther forward over the clypeus. Difference in the palpus are shown in the figures. Hairs of the median ocular area small and weak, instead of stout and erect.

Female with the median ocular area slightly longer than wide, the anterior median eyes being protruded farther forward; the anterior median eyes a full radius from the side eyes.

MEASUREMENTS:

	Female	*Male*
Length	2.40 mm.	2.10 mm.
Carapace:		
Length	1.20	1.00
Width	.87	.73
Tibia-patella:		
I	1.40	1.20
IV	1.53	1.27

Type locality: Olympia, Washington.

Other localities: Larabee Park, Washington; Lake Cameron, Vancouver Island, British Columbia. (R. V. Chamberlin and W. Ivie, collectors, September, 1935.) Collected by sifting leaves in woods.

Bishop and Crosby (1934) also record this species from Mt. Whiteface, New York.

The female allotype in the M. C. Z. collection, described by Banks (1893), and redescribed by Bishop and Crosby (1934), is evidently not a *Wubana*. The true female is described and figured here for the first time.

Wubana atypica Chamberlin and Ivie, new species
(Pl. V, Figs. 45–50)

This species is the largest of our Wubanas and the least typical.

Color: Light, differing from the typical as follows: Carapace lighter, being more yellowish than orange. Interocular area not black, though each eye is narrowly surrounded by black. The abdomen light yellowish gray to medium gray; the color may be uniform, slightly mottled, or a faint pattern of the typical form may be present. A white spot is present above the spinnerets as usual.

Structure: Female. Eyes slightly farther apart than typical, but the arrangements otherwise the same. Chelicera with only three teeth

on the upper margin. Legs and claws proportionately longer than typical. Abdomen and carapace also longer in proportion to width. The epigynum of the usual form.

Male—The cephalic elevation is more conical than hornlike; it rises between the posterior median eyes, is almost vertical in front, and slopes off gradually behind. The long hairs on top form a long curved tuft. The two hairs in the median ocular area small and inconspicuous.

The eye arrangements are distorted by the cephalic elevation. The posterior median eyes fully two diameters apart, and about two-thirds of a diameter from the lateral eyes. The anterior median eyes are a little more than a radius apart, and scarcely farther from the side eyes. Posterior median eyes slightly smaller than the laterals, but larger than the anterior median eyes. The clypeus is concave; the width is nearly four times the diameter of the anterior median eyes. The palpus in general typical.

Variations as noted above in the female also present in the male.

MEASUREMENTS:

	Female	*Male*
Length	3.30 mm.	2.85 mm.
Carapace:		
Length	1.47	1.40
Width	1.18	1.05
Tibia-patella:		
I	2.27	1.95
IV	2.27	2.07

Type locality: Larabee Park, Washington. Male holotype, female allotype; male and female paratypes. (R. V. Chamberlin and W. Ivie, collectors, Sept. 11, 1935.)

Other locality: Lake Cameron, Vancouver Island, British Columbia. Female paratypes. (R. V. Chamberlin and W. Ivie, collectors, Sept. 13, 1935.)

Collected by sifting leaves in woods.

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EXPLANATION OF PLATES

PLATE I

Fig. 1. *Wubana drassoides* (Emerton). 1. Female. 2. Male. 3. Male, lateral view, with legs removed from near side.

PLATE II

Fig. 4. *Wubana drassoides* (Emerton). 4. Female, lateral view of body. 5. Ventral view of female. 6. Spinnerets, ventral. 7. Front of male. 8. Carapace of female. 9. Carapace of male. 10. Chelicera, under side. 11. Foot. 12. Leg IV, anterior. 13. Eyes of female. 14. Horn of male, with hairs spread apart.

PLATE III

Fig. 15. *Wubana drassoides* (Emerton). 15. Male, lateral view of body. 16. Abdomen of a light colored specimen. 17. Left palpus, ventral. 18. Left palpus, mesal. 19. Left palpus, ectal. 20. Edge of conductor of palpus, ectal view, from Grand Canyon specimens. 21. Same from California specimens. 22. Epigynum, posterior. (Figs. 17–19 based on Utah specimens.)

Fig. 25. *Wubana utahana* n. sp. 25. Male, lateral view of body. 26. Abdomen. 27. Left palpus, ectal. 28. Epigynum, ventral. 29. Epigynum, lateral.

PLATE IV

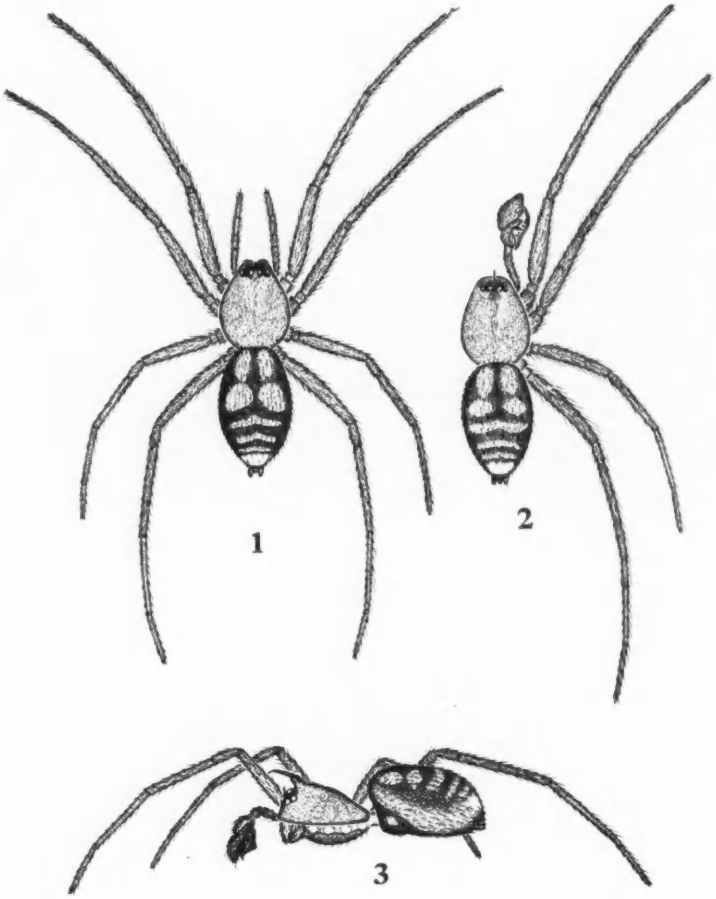
Fig. 30. *Wubana ornata* n. sp. 30. Male, lateral view of body. 31. Abdomen. 32. Left palpus, ectal. 33. Epigynum, lateral. 34. Epigynum, posterior.

Fig. 35. *Wubana suprema* n. sp. 35. Male, lateral view of body. 36. Abdomen. 37. Front of male. 38. Left palpus, ectal. 39. Left palpus, ventral.

PLATE V

Fig. 40. *Wubana pacifica* (Banks). 40. Male, lateral view of body. 41. Abdomen. 42. Left palpus, ectal. 43. Epigynum, lateral. 44. Epigynum, posterior.

Fig. 45. *Wubana atypica* n. sp. 45. Male, lateral view of body. 46. Abdomen. 47. Left palpus, ectal. 48. Epigynum, lateral. 49. Epigynum, posterior. 50. Chelicera, under side.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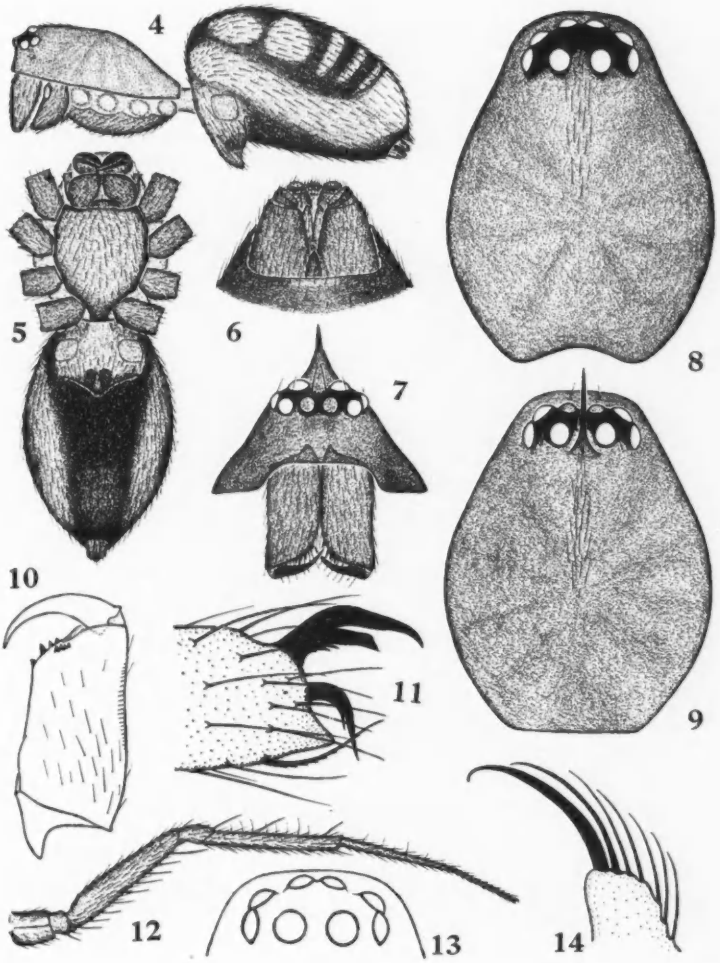
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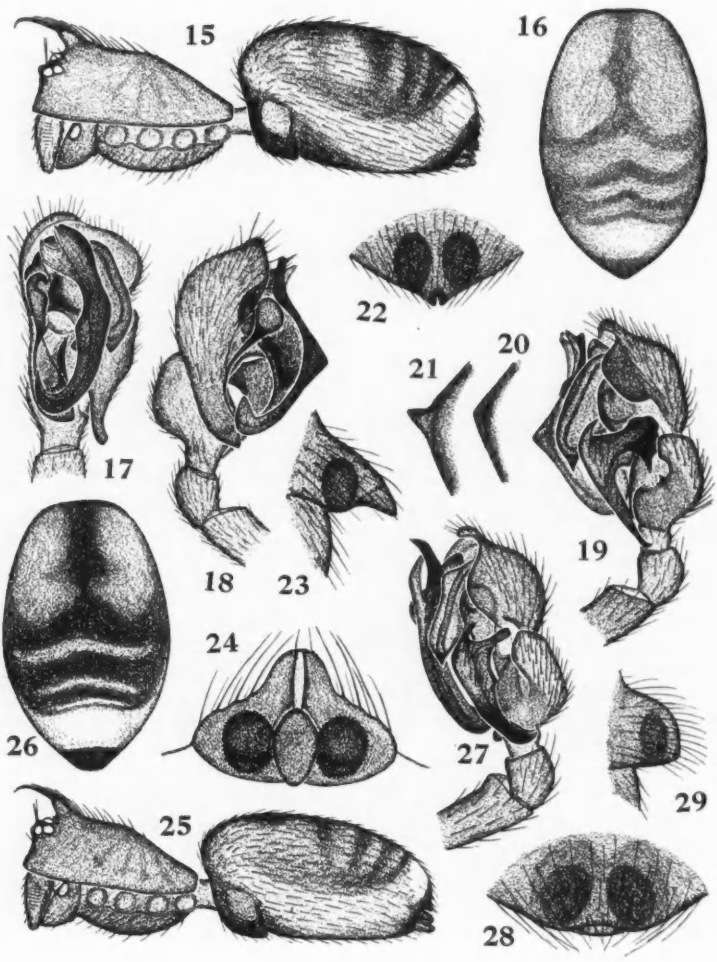
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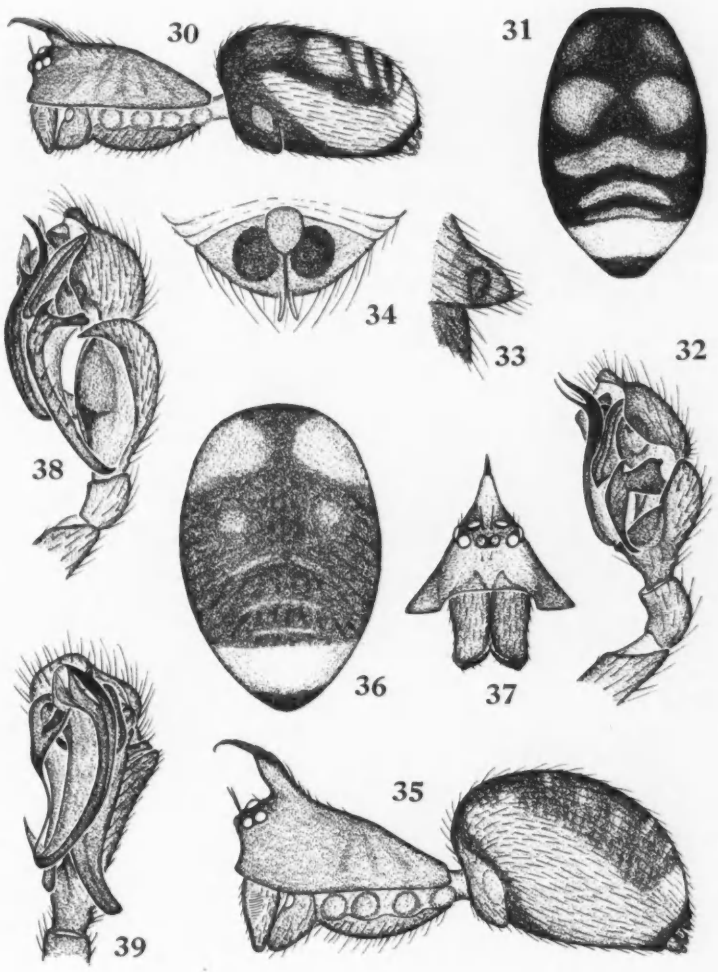
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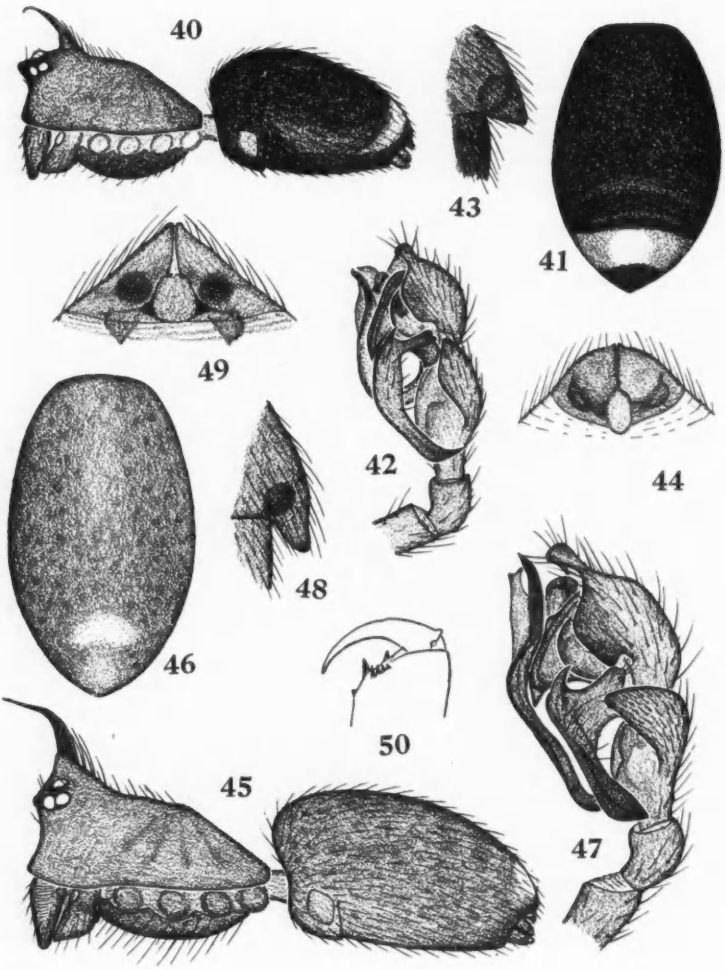
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THE ANCESTRY AND WING VENATION OF THE HYMENOPTERA[1]

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Few problems in insect wing venation have brought forth such a mass of contradictory explanations and opinions as the question of the interpretation of the hymenopterous wing. In only a few cases are either the premises or the interpretations remotely similar; most of them are radically different. Due to these discrepancies it seems advisable to reopen the question for further analysis. By way of introduction the more fully explained interpretations will be presented briefly. A more complete summary is given by Rohwer and Gahan (1916).

The first modern attempt at homologizing the veins of the hymenopterous wing with those of other insects was undertaken by Comstock (1895). His interpretation was later modified by MacGillivray (1906). The interpretation of these two authors has been accepted in most general texts in this country up to the present day. It was originally based almost entirely on an analogy with the behavior of the vein Cubitus 2 in the wings of specialized Diptera. The bending backward of this vein in *Rhamphomyia* and *Musca* was applied to practically all the veins to produce a supposedly hypothetical hymenopterous wing. The result of the gross application of this analogy seems so artificial and complicated that it is apparently untenable even at first glance. Furthermore, it does not seem reasonable to draw such an extreme parallel between insects so far removed phylogenetically.

Handlirsch (1908) proposed a radically different system on the basis of the pupal tracheation of *Tremex*. He did not suppose any recurrent action of the veins but instead suggested that certain veins had atrophied completely.

Forbes (1925) outlined another scheme of interpretation based on the pupal tracheation and the application of certain principles found true of the coleopterous wing. In certain

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particulars this is similar to that of Handlirsch, since it supposes a reduction of the branches of the principal veins and the presence of a considerable number of cross-veins. It is questionable whether the Coleoptera and Hymenoptera have any close phylogenetic relation, so that a comparison between the two is entirely problematic. Furthermore, the coleopterous wings considered are the hind wings, which are the only ones that function in flight. In the Hymenoptera both wings are used in flight and it is not likely that under these circumstances the same conditions would be evolved.

The use of the tracheation of the pupal wings as an aid to the interpretation of the adult wings is also open to question in the Hymenoptera. Comstock (1918, p. 370) states about the honeybee that "an examination of the wings of young pupae of this insect revealed the fact that the laying out of the wing venation precedes the tracheation of the wing. After the wing-veins reach that stage of development in which they appear as pale bands, the tracheae grow out from the base of the wing into them. . . . It is obvious that tracheae developed after the vein cavities are formed will follow the paths offering the least resistance to their progress; and it is not to be expected that they will preserve their primitive arrangement under these conditions." I have examined several pupae of *Cladius pectinicornis* and *Euura salicis-nodus* and have found this condition to be true for these two species also. The cells of the adult wing are blocked out in the pupal wing before any tracheae enter it; and the course of the tracheae follows the weak areas corresponding to the adult venation. There is little uniformity in the course which all the tracheae take; even in the same species differences are found which would upset any proposed homologies. Pupal wings of *Euura*, *Cladius*, *Sceliphron*, and *Formica* which have been studied and published illustrations of *Apis*, *Tremex* and *Ceratina* differ greatly from each other, not only in regard to the paths of the tracheae, but also in the number of branches, and the fusion of the various tracheae at the base of the wing. From this it is clear that the pupal wing tracheation is not an accurate guide to the homologies of the adult veins of the Hymenoptera.

The interpretation of Tillyard (1924) was based upon the venation of the fossil order Protohymenoptera. Tillyard supposed this order to be the progenitor of the modern Hymenoptera and, therefore, that the venation of the one applied to the other.

Carpenter (1930) has shown fairly conclusively that Tillyard was in error (1) in the original interpretation of the venation in the Protohymenoptera and (2) in supposing the protohymenoptera to be allied to the Hymenoptera, since the former are apparently close relatives of the Megasecoptera.

In view of the discrepancies in these interpretations and the basic reasoning to produce them, it is evident that information only from within the order is inadequate to determine the homologies of the hymenopterous venation. For this reason it was decided to determine as closely as possible the nearest ally of the Hymenoptera and endeavor to deduce the venation from this relative.

THE ANCESTOR OF THE HYMENOPTERA

The greater part of the evidence compiled by the various authors indicates fairly clearly that the Hymenoptera show distinct affinities with the mecopteroid or panorpoid orders, especially the Megaloptera, Mecoptera and Trichoptera. The more apparent features possessed in common by these orders and the Hymenoptera include (1) similar number and texture of wings, (2) similar divisions of the mesonotum and to some extent the shape of the mesofurcae, (3) an invaginated mesopostnotum, (4) similar tendencies to produce an ala- or totaglossa by the fusion of labial parts and (5) some similarities in the larval stages.

Crampton (1926) places the Hymenoptera closest to the Coleoptera on the basis of the precoxal bridge in the sawfly family Cimbicidae. This, however, is a specialized condition within the sawflies and not the primitive one from which such homologies should be deduced. In fact, on the basis of the cervical and propleural region in other sawflies there is little doubt but that the hymenopterous cervical sclerites evolved from a type similar to those of the Trichoptera or Mecoptera.

The placement of the order on the basis of wing venation has led to some misconceptions, especially on the part of Crampton (1927). As pointed out by Carpenter (1930), the similarities in many wings with reduced venation are due to parallel evolution and are not an indication of relationship. Martynov (1930) expresses the opinion that the venation of the hymenopterous wing shows many points of similarity with the venation of some of the panorpoid orders.

On the basis of the few available characters the theory of Martynov and others, that the Hymenoptera arose from the panorpoid complex seems justified. On the whole the evidence is fairly strong, for one must remember that, as yet, basic morphological characterization which will definitely place them in a phylogenetic series has been given to only a few orders.

An additional argument for considering the Hymenoptera as closely related to the panorpoid complex is that it has been possible to make a fairly satisfactory derivation of the hymenopterous wing from panorpoid wings.

THE FRONT WING

The venation of the hymenopterous wing, Fig. 3, is at once seen to be considerably reduced when compared to a fairly primitive insect wing, Fig. 2. This is particularly true of the apparently longitudinal veins. In proportion to the number of these the apparent cross-veins are fairly numerous. Of all the Hymenoptera, the sawflies have the wings with the largest number of veins. A perusal of these shows that certain of them have veins not possessed by the others, such as the Xyelidae, Fig. 9, Siricidae, Fig. 4, and Megalodontidae. If we make up a hypothetical wing possessing all of these veins we have as our product Fig. 5. The question in hand is to trace this from the panorpoid type of wing, providing our selection of the hymenopterous ancestor is correct.

Axillary sclerites and the anal veins: The axillary sclerites give the first clue to the positive identity of some of the veins. In all the panorpoid orders the anal veins articulate with axillary sclerite 3Ax, and Cubitus arises from the median sclerite, m, Fig. 1. In the Megaloptera (particularly *Sialis*) Figs. 1, 14, Mecoptera, Fig. 15, and Trichoptera, Fig. 19, the first three anal veins arise very close together; first anal is much the larger, markedly convex and articulates with sclerite 3Ax. In the hymenopterous wing, Figs. 7, 16, the veins labelled "1A," "2A" and "3A" arise close together at the base; "1A" is the largest, is very markedly convex and articulates with sclerite 3Ax. There seems no doubt from this that in the hymenopterous wing these are the true anal veins. The fourth anal or fibular vein is readily identified as the stub in the fibular area, Fig. 7.

It is a fairly easy matter to derive the shape of these veins and cells in the sawflies from the various conditions present in the panorpoid orders. In *Sialis*, Fig. 14, first anal is unbranched and joined to second anal by a cross-vein. In *Panorpa*, Fig. 15, a certain amount of reduction has taken place: second anal is unbranched, connected to first anal by two short cross-veins, and the entire anal region has become considerably narrowed; furthermore the apices of the anal cells are closed by the vein-like margin of the wing. It is but a short step from this condition to that in *Tremex*, Fig. 16. Here first anal is joined to second anal by only one cross-vein; second anal has followed the margin of the wing and ultimately fused with first anal near the marginal incision; the portion of third anal beyond the cross-vein has atrophied, and the base of third anal and the cross-vein have blended into a continuous arc joining second anal near its base.

In most sawflies second anal proximad of the point of fusion with third anal has completely atrophied, Figs. 17, 18, resulting in the curious basal anal cell with its basal constriction. In the Siricinae it is third anal which atrophies, resulting in the basal anal cell being long and tapering at the base.

Cubitus and Media: We would expect Cubitus to lie immediately in front of the first anal vein, arising from the axillary sclerite m, (Fig. 1). In the wings of existing Hymenoptera no such well defined vein exists. There is, however, an indistinct vein in the Xyelidae arising near sclerite m, Fig. 7, and running along the concavity or furrow in front

of the first anal vein. In some other sawflies, e. g., *Incalia* and *Pamphilius*, there is an apparent cross-vein running from the base of the concavity to the strong, convex vein immediately in front. A combination of these two conditions has been found in a specimen of *Macroxyela ferruginea*, Fig. 23, having an arrangement similar to that in our hypothetical wing.

A ready explanation for this is given by an examination of the condition of Cubitus in some of the panorpoid wings. In the front wing of *Panorpa*, Fig. 20, the base of Cubitus is weak and concave, splitting into Cubitus 1 and Cubitus 2, the latter remaining concave, the former becoming convex. The base of Media is likewise convex, as is the short cross-vein connecting Media and Cubitus 1; and these three form a continuous convex area from the base of Media to the apex of Cubitus 1. In the front wing of another mecopteron, *Bittacus*, we find the same condition except that Cubitus 1 fuses with Media for a short distance, much as in Figure 22. This forms a strong and continuous serial vein which again is convex from the base of Media to the apex of Cubitus 1. In many of the Megaloptera, e g., *Sialis*, Fig. 22, exactly the same condition exists. In the front wings of many Trichoptera a condition essentially similar is the rule, Fig. 21. The chief difference is that frequently Cubitus 1 does not fuse with Media but is connected to it by a cross-vein (the posterior arculus) in such a fashion as to form a convex, serial vein similar in appearance to that in *Bittacus* and *Sialis*.

In comparison with the above four illustrations it is possible to identify the veins labelled "Cu," "Cu_1" and "Cu_2" on our hypothetical hymenopterous wing, Figs. 5, 23, as Cubitus and its branches and the vein labelled "M" as Media. Cubitus is the obsolescent, concave vein arising near sclerite m and running parallel to the base of Media. It forks after a short distance and Cubitus 2 continues as an almost obsolete vein very close to the first anal vein. Cubitus 1 fuses with Media, which soon leaves it and branches forward; Cubitus 1 then continues in line with the base of Media, angles to the hind margin of the wing and divides into two branches. The base of Media, the portion consisting of Media plus Cubitus 1, and the apical portion of Cubitus 1 form our familiar strong, convex serial vein, joined to the base of Cubitus by the base of Cubitus 1, which appears as a cross-vein.

The Xyelidae, Fig. 23, are the only sawflies known to possess a vestige of the base of Cubitus and Cubitus 2, and the Loboceridae, Siricidae and Megalodontidae have the only representative with the base of Cubitus 1 present as a constant vein. In all other sawflies known these parts are entirely absent, Fig. 3, leaving no clue to the identity of the cubital veins.

In the Megaloptera and Mecoptera there is usually a cross-vein connecting Cubitus 1 with Cubitus 2 and another connecting Cubitus 2 with first anal. Presumably these two, upon the atrophy of Cubitus 2, have aligned themselves together to form a cubito-anal cross-vein, cu-a, in the hymenopterous wing.

Tillyard (1932) has advanced the hypothesis that in the Megaloptera Cubitus 2 has atrophied and been replaced by Cubitus 1b. His de-

ductions are based primarily on the fossil wings *Permoraphidia* and *Martynovia*. At first glance it would seem that in the Megaloptera, Mecoptera and Trichoptera the vein labelled Cubitus 2 was homologous. A study of the contours of the wings, Figs. 32–35, shows that, in each, Cubitus 1 and first anal are very convex, but that Cubitus 2 varies. In the Mecoptera, Fig. 33, Trichoptera, Fig. 34, and Hymenoptera, Fig. 35, it is absolutely concave, being situated at the very bottom of the cubital furrow. In these three orders this concave condition would seem to identify the vein positively as Cubitus 2 and not a branch of Cubitus 1. In the Megaloptera, Fig. 32, the vein in question is neither convex or concave, being situated partway up the anterior slope of the cubital furrow. This apparently offers no proof either way. Viewing this uncertainty along with the vein's apparent homologue in the other three orders, it seems advisable to retain the name Cubitus 2 until more adequate reasons are given for considering that it has atrophied in these orders.

Up to this point we have established the identity of the anal and cubital veins and the base of Media. From the position of these veins the portion labelled "R" will be the base of Radius. Anterior to Cubitus 1, however, it seems impossible to find landmarks or vestiges to aid in homologizing the veins. The analysis will therefore be continued from the anterior or costal margin.

Costa: The thickening of the anterior margin of the wing, Fig. 5, C, is at once recognized as Costa. It continues almost to the stigma, from which it is separated by a distinct break.

Subcosta: Immediately posterior to Costa is Subcosta, Sc, readily identified by the humeral cross-vein, h, which connects it to Costa at the base. Subcosta divides before the stigma into two branches; the anterior branch, Subcosta 1, joins Costa, and the posterior branch, Subcosta 2, fuses with Radius.

Stigma: The stigma is the heavily sclerotized area on the anterior margin of the wing, and is characteristic of most winged Hymenoptera. Its formation is easily traced from the panorpoid groups, where it is represented by an opaque area between the apical free parts of Subcosta 2 and Radius 1.

Radius: Having established "M" as the base of Media, Fig. 5, the part labelled "R" is therefore the base of Radius. The first branch from it should be the radial sector, labelled "Rs." This, it will be noted, has fused with the second abscissa of Media. Considering radial sector thus makes imperative the identification of the parts labelled "1r" and "2r." Returning to the wings of the Megaloptera and Mecoptera, we find that there are usually at least two cross-veins between Radius 1 and radial sector or its branches. One of the cross-veins arises from the body of the stigmal area and another from near its base. If a third is present it is considerably proximad of this point. In the hymenopterous wing the distal one arises from the body of the stigma and the proximal one from near the base of the stigma. From the standpoint of location, therefore, there is no objection to designating these as two radial cross-veins. It further identifies the posterior margin of the stigma as Radius 1, which continues beyond the stigma along the anterior margin of the wing.

Reduction of Radius and Media: Distad of the fusion of Media and radial sector there are only two apparent longitudinal veins to account for the typical four branches of radial sector and four branches of Media. The solution to this quandary seems the most puzzling problem of the entire wing. Obviously a considerable reduction of some kind has taken place. The net result seems to be that radial sector and media have each become resolved into a single branch, duplicating the condition found in some Corrodentia, Figs. 25, 26. There are no distinct landmarks in the hymenopterous wing, however, to uphold or refute this surmise.

The number of reduction plans which would give such a condition are manifold. Three are diagrammed in Figs. 27–29. It was thought that wing furrows might give some clue to this situation. A pair of fairly constant furrows were found in the front wings of many Tenthredinoidea as in Fig. 30. This is probably a corroboration of the arrangement suggested in Fig. 29, but cannot be taken as conclusive. If a front wing of *Sialis* be drawn with the atrophy of these veins indicated, Fig. 24, the result is very similar to our hymenopterous wing. Another interesting feature for speculation is illustrated in Fig. 31. In some specimens of *Pleroneura* the branches of radial sector may proliferate as shown. There is again a marked similarity between this condition and the proliferations of the same veins in the wing of *Sialis*, Fig. 24. The cross-veins (see below) give indirect substantiation of this arrangement, so that an accumulation of circumstantial evidence favors the type of reduction shown in Figs. 28 or 29, rather than that in Fig. 27.

Another possible bit of evidence is given by the nygmata. Forbes (1924) has shown that in many forms of Neuroptera and Mecoptera these dots (the nygmata) occur between Radius 5 and Media, which is also the case in the Hymenoptera if the present hypothesis is correct.

The practical application of this selection is frought with difficulties. It is impossible to tell exactly where radial sector or Media branched to give rise to the atrophied veins, so that the terms "Rs," "R_{2+3}," "M," or "MA" cannot be used definitely for exact parts of these veins distad of their fusion. Consequently it seems better to use Rs and M in a more or less artificial manner as names for the two longitudinal veins in question. This has been done for the following reasons: (1) since the exact homology of the veins is in doubt the adoption of these artificial terms would lead to a more stable nomenclature in view of the certain dispute of their exact composition; (2) as aforesaid, it may be impossible to designate the abscissae with certainity even though their homology became completely known; (3) the terms form very convenient "handles" for use in systematic work, which, after all, will be their chief use.

Cross-veins: The hymenopterous wing possesses several supernumerary cross-veins in the distal and anal portions of the wing. Thus we have two between Radius 1 and radial sector, two (sometimes three) between radial sector and Media, two between Media and Cubitus 1, one between Cubitus 1 and first anal, and one between first and second anal. Not only the number but also the position of these cross-veins is practically the same as in the *Sialis* wing. This similarity seems too

great for a simple coincidence and again suggests a close relationship between the Megaloptera and Hymenoptera.

In some Xyelids (*Pleroneura*, Fig. 9, and *Xyela*) radial sector and Media do not fuse but are connected by a short cross-vein, 1r-m, as in *Sialis*. This apparently constitutes the first radio-medial cross-vein which is always present in the hind wing. This feature has not been incorporated into the hypothetical wing since its presence seems to add nothing to the elucidation of the wing. In the discussion above regarding Figs. 27 and 28, the question would be whether it was a cross-vein or the base of anterior media, MA.

A reduction of the longitudinal veins does not necessarily imply a corresponding reduction of the cross-viens, as is well shown in the wings of stoneflies and many of the fossil groups. It is quite possible, therefore, for the same thing to happen in the hymenopterous wing. In insect wings the cross-veins frequently align themselves transversely across the wing, as in many of the Lepidoptera, Trichoptera and Plecoptera. Also, when a branch of a vein drops out, the cross-veins seem to arrange themselves between the remaining veins in much the same manner as they were before. Consequently, if the reduction of the longitudinal veins occurred in the hymenopterous wing as postulated above, the cross-veins of the original parent wing would likely align and arrange themselves between the remaining veins in much the same pattern as they occurred in the parent wing.

GENERAL APPEARANCE

The hymenopterous wing resembles no other insect wing in appearance. The longitudinal veins have become extremely angulate at certain points where cross-veins are attached to them, and some of the cross-veins have become longer than the usual conception of a cross-vein. The reason for this is likely the method by which the two wings of a side are joined in flight. The hind wing is provided with a set of small hooks or hamuli, Fig. 10, ham, which are hooked under the hind margin of the front wing in flight below the second anal cell. Thus the hind wing will exert a definite pull on the front wing. A considerable amount has been written by MacGillivray (1906) and Tillyard (1924) on the effect of this arrangement on the outline of the wing and the shape of the cells. It is probably the primary reason for the reduction of the venation, since undoubtedly the fewer, but stronger, veins of the hymenopterous wing are a better bracing apparatus than the more numerous, weaker veins of the panorpoid wings. The chief modifications resulting in angulations of the veins have occurred in the transverse area between the point of attachment of the hamuli and the base of the stigma; and it is undoubtedly across this region that the greatest pull is exerted. This probably explains the disarrangement of the venation in this area.

THE HIND WING

The hind wing, Fig. 10, is entirely different in shape from the front wing. The anterior margin is straight and the posterior margin is rounded, with a large anal lobe. At first glance the venation appears

to be entirely different, but a closer examination shows that the scheme of modification has been similar in the two wings.

The hind wings of some of the Tenthredinoidea, Fig. 11, most closely resemble the front wings. Matching up the veins of both wings, we arrive at the following solution of the venation of the hind wing:

Subcosta is completely fused with Radius.

Radius divides into R_1 and Rs; a radial cross-vein has been found only in the genus *Adelomos*.

Media separates from Radius near its base, fuses with Cu_1 for a considerable distance, then separates from it and proceeds to the margin of the wing. It is connected to Rs by 1r-m and 3r-m. The cross-vein 2r-m is found only in some Xyelidae, Fig. 10.

Cubitus is represented only by the portion of Cu_1 fused to Media and the portion beyond their separation; this apical abscissa of Cu_1 does not divide into Cu_{1a} and Cu_{1b} as in the front wing. It is typically connected to Media by the medio-cubital cross-vein. In *Macroxyela ferruginea*, Fig. 10, a vestige of Cubitus and the base of Cu_1 remains as a faint loop between the axillary sclerite m and the serial vein M & M+Cu_1 & Cu_1.

The anal veins are four in number as in the front wing. 1A and 2A proceed sub-parallel to each other and to M+Cu_1; 1A typically reaches the margin of the wing, connected to Cu_1 by the cubito-anal cross-vein (cu-a) and to 2A by the anal cross-vein (a); 2A only rarely extends beyond the anal cross-vein as in Fig. 11, usually forming a continuous loop with this cross-vein, joining 1A, Fig. 12. 3A has migrated to the anal lobe and is fused with 4A, which appears as a stub at the base of 3A.

It will be noted that in the hind wing Media does not fuse with the basal portion of radial sector. In this it differs from the front wings of all sawflies except some Xyelids, Fig. 9, in which the same condition exists in both wings. Another item of interest is the straightness of the veins of the hind wing as compared to their contorted condition in the front wing. This is good testimony that the tortuous path of the veins of the front wing is due to the physical requirements of the wing rather than to the complexity of the venation.

CELLS

The system of cell terminology in general use, i. e., naming them for the vein forming their anterior boundary, can be applied without difficulty to most of the hymenopterous wing. Where, however, the atrophy of veins has caused the union of more than one cell it seems advisable to use an abbreviated expression. This is especially desirable for taxonomic use. Such a system is given in Figure 3, which is the common type of venation met with in the sawfly groups. The chief deviations from the standard are the anal cells and the medio-cubital cell. The latter would otherwise be 1st. M+1st. Cu_1+Cu.

REVIEW

The venational scheme advocated in this paper for the Hymenoptera is in most respects a direct, simple derivative

of the type in the Megaloptera and Mecoptera. When considered as supplementary to the evidence cited above (p. 103+), this affinity of the venation indicates fairly conclusively that the Hymenoptera arose from the Megaloptera-Mecoptera stem. This viewpoint, and also the venation proposed, was somewhat anticipated by Woodworth (1906), who stated that the hymenopterous venation could be derived from that of the Trichoptera. While this latter order is also a close relative of the Megaloptera and Mecoptera, it has certain differences which practically exclude it from the line of ancestry of the Hymenoptera, such as a lack of supernumerary cross-veins, specialized anal region (Fig. 6) and differences in the sclerites of the thorax.

In those Trichoptera which possess hamuli and have the front and hind wings joined in flight in the same manner as the Hymenoptera, a similar shape of wing has been evolved, but this is accompanied by its own peculiar modification of radial sector and Media (Fig. 6), quite unlike that in the Hymenoptera. Furthermore, the modification of the specialized Trichoptera may be traced from the more generalized members of the same order (Betten, 1913). Here again, however, may be remarked the similar evolution of Cubitus in the four orders discussed in this paragraph.

A summary of the venational scheme proposed is best obtained by reference to Figures 5 and 10.

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EXPLANATION OF PLATES

Plate I

Fig. 1, Alar sclerites of front wing of *Sialis infumata* (Neurop.). 2, Front wing of *Sialis infumata*. 3, Front wing of *Caliroa aethiops* (Hymen.). 4, Front wing of *Tremex columba* (Hymen.). 5, Hypothetical hymenopterous wing. 6, Front wing of *Leptocella* sp. (Trichop.). 7, Alar sclerites of front wing of *Macroxyela ferruginea* (Hymen.). 8, Hind wing of *Sialis infumata*. 9, Front wing of *Pleroneura* sp. (Hymen.). 10, Hind wing of *Macroxyela ferruginea*. 11, Hind wing of *Arge dulciaria* (Hymen.). 12, Portion of hind wing of *Hemichroa crocea* (Hymen.) 13, Hind wing of *Syntexis libocedrii* (Hymen.)

Plate II

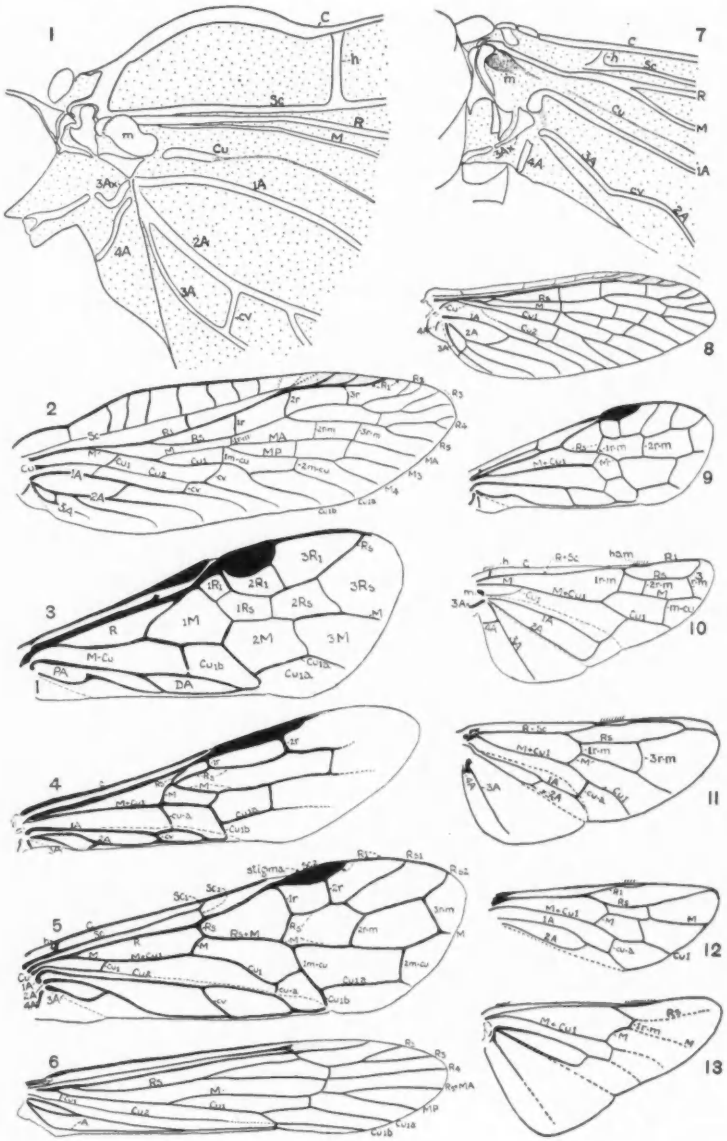
Fig. 14, Anal region of front wing of *Sialis infumata*. 15, Anal region of front wing of *Panorpa sigmoides* (Mecop.). 16, Anal region of front wing of *Tremex columba*. 17, Anal region of front wing of *Caliroa aethiops*. 18, Anal region of front wing of *Macroxyela ferruginea*. 19, Anal region of front wing of *Rhyacophila* sp. (Trichop.). 20, Cubital region of front wing of *Panorpa sigmoides*. 21, Cubital region of front wing of *Rhyacophila* sp. 22, Cubital region of front wing of *Sialis infumata*. 23, Cubital region of front wing of *Macroxyela ferruginea*. 24, Diagrammatic front wing of *Sialis infumata*. 25, Front wing of *Psocus* sp. (Corrodentia), after Comstock. 26, Hind wing of *Psocus* sp., after Comstock. 27, 28, 29, Reduction possibilities of radial sector and Media in the Hymenoptera. 30, Front wing of *Dolerus similis* (Hymen.). 31, Radius of front wing of freak specimen of *Pleroneura* showing proliferation of radial sector. 32, Cross section of cubital region in front wing of *Sialis infumata*. 33, Cross section of cubital region of front wing of *Bittacus apicalis* (Mecop.). 34, Cross section of cubital region of front wing of *Rhyacophila* sp. 35, Cross section of cubital region of front wing of *Macroxyela ferruginea*.

Abbreviations Used for All Figures Except Fig. 3

a—anal cross-vein.
1A, 2A, 3A, 4A—first to fourth anal veins respectively.
3Ax—third axillary sclerite.
C—Costa.
Cu, Cu_1, etc.—Cubitus and its branches.
cu-a—cubito-anal cross-vein.
cv—cross-vein.
h—humeral cross-vein.
m—median axillary sclerite.
M, M_1, M_2, etc.—Media and its branches.
MA—anterior branch of Media.
MP—posterior branch of Media.
m-cu, 1m-cu, etc.—medio-cubital cross-veins.
r, 1r, etc.—radial cross-veins.
R, R_1, etc.—Radius and its branches.
Rs—radial sector.
Sc, Sc_1, Sc_2—Subcosta and its branches.

Abbreviations Used for Fig. 3 (Cells)

Cu_1a—cell Cubitus 1a.
Cu_1b—cell Cubitus 1b.
DA—distal anal cell.
1M, 2M, 3M—first to third medial cells, respectively.
M-Cu—medio-cubital cell.
PA—proximal anal cell.
R—radial cell.
$1R_1$, $2R_1$, $3R_1$—first to third cell Radius 1, respectively.
1Rs, 2Rs, 3Rs—first to third cell "Rs," respectively.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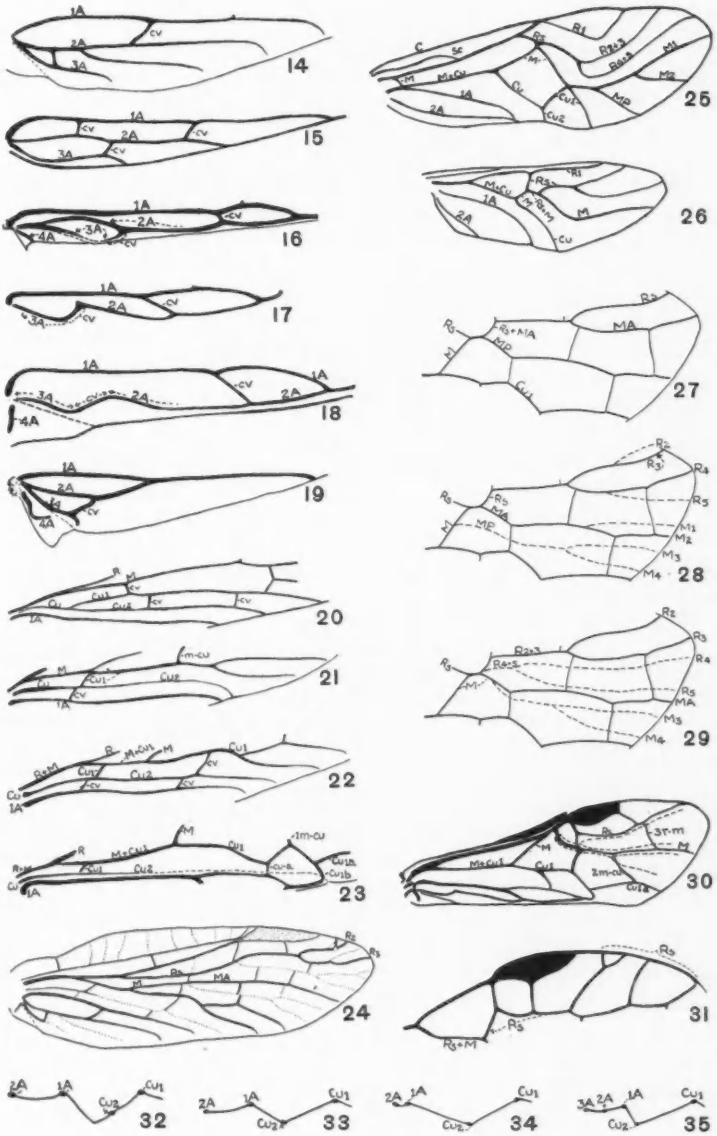
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ON THE TOTAL HEMOLYMPH (BLOOD) CELL COUNTS OF INSECTS

II. Neuroptera, Coleoptera, Lepidoptera and Hymenoptera

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This paper is a report of further studies made upon the total hemolymph cell counts of insects. Thus far counts have been obtained only from nymph-possessing species, previous reports having to do with counts from the field cricket and from other heterometabolous Orthoptera, Odonata, Hemiptera and Homoptera (1934, 1935). The counts described here are all from larva-possessing (holometabolous) species. Hollande (1930) states that Aghar (1928) determined total counts in *Pieris brassicae* L. and *Aporia crataegi* L.; with this exception, the authors have found no report in the literature of total hemolymph cell counts from holometabolous insects.

MATERIALS

The insects used in this study were collected at random in the vicinity of Ames, Iowa. When practicable insects were collected and utilized on the same day. Phytophagous forms were placed in vials with portions of the host plants, whenever possible, and counts made as soon as convenient. The four larvae of *Osmoderma eremicola* were found in June in the decaying trunk of a fallen cottonwood tree. A quantity of the rotting wood was taken to the laboratory with the grubs, and after the hemolymph samples were taken for the counts, the animals were placed in a loosely covered jar containing some of the material which formed their normal habitat. Two (a male and a female) of the four grubs survived, pupated and emerged in late March as adults of the hermit flower-beetle; a week later they were used again for counts.

Attempts to obtain sufficient hemolymph for cell counts were unsuccessful with the following insects: two species of tiger beetles (Cicindelidae), three species of ants (Formicidae), two species of bumblebees (Bombidae), the house fly (*Musca domestica*), one species of flesh fly (Sarcophagidae), one species of horse fly (Tabanidae), two species of sawflies (Tenthredinidae), three species of ichneumon wasps (Ichneumonidae), one species of digger wasp (Scoliidae), one species of hornet (Vespidae) and several species of adult Lepidoptera. These failures are evidence of the small total blood volume in the imagos.

METHOD

The procedure used here for determining total hemolymph cell counts from untreated insects and from insects treated with acetic acid vapor to prevent cell coagulation is that previously used by the authors (1934, 1935) for the determination of total counts in nymphs and imagos of heterometabolous species.

Hemolymph samples were obtained, as indicated in Table I from either antennae, legs, both antennae and legs, heart (direct puncture) or hemocoele (puncture through body wall). These variations were necessary in order that a sample could be collected in a short time from adult insects which do not bleed freely from the cut antennae alone, or from mature insects whose antennae are so morphologically constructed that they are not convenient for hemolymph sampling. Samples from larvae were obtained by clipping a leg or by direct heart puncture and samples from pupae by puncturing the lateral body wall with a needle. With the exception of the four grubs of *Osmoderma eremicola* and a few larvae of *Neodiprion lecontei*, all larvae were treated with glacial acetic acid vapor to prevent the rapid hemolymph (blood) coagulation that has been found to occur in many of the larval forms. Some of the smaller insects that are bled with difficulty and others that bleed slowly were subjected to this anticoagulant procedure.

RESULTS

The results of the 237 hemolymph cell counts from the 29 species of insects are given in condensed form in Table I. The different species are separated into 4 orders (column 1). With only a few exceptions, the scientific and common names are given for each form (column 2). Developmental stages are designated (column 3) by *A* (adult), *L* (larva) and *P* (pupa); if counts were made from two different stages, both are indicated. Wherever possible, the sex of the insect is indicated (column 4); if this factor could not be determined, a "?" is used. As utilized in column 5, the term "normal" signifies that, as far as the authors could determine, the animals so indicated were in no special physiological or pathological state when the hemolymph sample was taken; when any unusual condition such as parasitism, ecdysis, oviposition, etc., was observed, the distinction is noted. The use or non-use of anticoagulant measures is marked (column 6) for each group by the signs "+" and "—"; or by "+—" if only some of a group were subjected to the acid vapor. The method and place of obtaining hemolymph samples are indicated in column 7. Number of individuals used is given in column 8. Highest and lowest counts from each group are given (column 9) to indicate, so far as this study is concerned, the range of counts from that particular group. An average count is placed in column 10 for each sex and stage of a species, wherever these figures are available; also an average value (in italics) is given for all normal individuals of the species, taken as a single group. The standard deviations (σ) of the larger groups are given with the means.

TABLE I

AVERAGE TOTAL HEMOLYMPH CELL COUNTS FROM NEUROPTERA, COLEOPTERA, LEPIDOPTERA, AND HYMENOPTERA

1	2	3	4	5	6	7	8	9	10
Order	Species	Stage of Development	Sex of Insect	Condition of Insect	Anticoagulant	Sample from	Number Observed	Range of Counts (cell/mm³)	Average Count ± σ
NEUROPTERA	*Chrysopa* sp.? golden-eyed fly	A	♂, ♀	Normal	—	Antennae, legs	54	2,119–3,248	2,533 ± 245
	" " "	L	♂, ♀	Normal	+	Antennae, legs	6	35,580–40,823	37,681 ± 1,984
	" " "	A, L	♂, ♀	Normal	+ —	Antennae, legs	60	2,119–40,823	*6,048*
COLEOPTERA	*Galerita janus* Fab.: ground-beetle	A	♂, ♀	Normal	—	Legs	5	59,655–76,665	*68,328*
	Harpalus pennsylvanicus Dej.: ground-beetle	A	♀	Normal	—	Legs	2	22,830–25,155	*23,993*
	Scarites substriatus Hald.: ground-beetle	A	♂, ♀	Normal	—	Legs	6	10,080–14,365	*12,680 ± 1,685*
	Creophilus sp.? rove-beetle	A	?	Normal	—	Legs	2	11,910–12,743	*12,327*
	Photinus sp.? fire-fly	A	♂	Normal	—	Legs	1	.....	*15,666*
	" "	A	♂, ♀	Bacteria in hemolymph	—	Legs	2	26,655–28,163	27,409
	Alaus oculatus L.: eyed elater	A	♂	Normal	—	Legs	1	.....	8,820
	" "	A	♀	Normal	—	Legs	1	.....	9,825
	" "	A	♂, ♀	Normal	—	Legs	2	8,820–9,825	*9,323*
	Elateridae: click-beetle	L	?	Normal	+	Heart puncture	2	23,155–23,655	*23,905*
	Coccinellidae: lady-bug	L	♂, ♀	Normal	+	Legs	8	55,163–58,493	*56,448 ± 1,212*
	Meracantha contracta Beauv.: darkling beetle	A	?	Normal	—	Legs	1	.....	*45,330*
	Phyllophaga sp.? No. 1 May-beetle	A	♂, ♀	Normal	+	Legs	8	8,140–10,920	10,090 ± 948
	" "	L	?	Normal	+	Legs	11	36,825–92,598	56,856 ± 16,952
	" "	L	?	Bacteria in hemolymph	+	Legs	3	102,578–112,995	107,413
	" "	A, L	♂, ♀	Normal	+	Legs	19	8,140–92,598	*37,165*
	Phyllophaga sp.? No. 2 May-beetle	A	♂, ♀	Normal	+	Legs	8	11,050–21,290	*14,506 ± 4,301*

1	2	3	4	5	6	7	8	9	10
COLEOPTERA	*Osmoderma eremicola:* hermit flower-beetle	A	♂	Normal	—	Legs	1		16,876
	" " "	A	♀	Normal	—	Legs	1		28,432
	" " "	A	♂, ♀	Normal	—	Legs	2	16,876–28,432	22,654
	" " "	L	♂, ♀	Normal	—	Heart puncture	4	23,910–44,325	33,493
	" " "	A, L	♂, ♀	Normal	—	Legs, heart puncture	6	16,876–44,325	*29,880*
	Nyctobates pennsylvanica DeG.: darkling beetle	A	♂, ♀	Normal	—	Legs	6	16,575–23,160	*20,216 ± 2,681*
	Dorcus sp.? stag-beetle	A	♂, ♀	Normal	—	Legs	7	37,905–62,160	*46,412 ± 8,146*
	Aegomorphus decipiens Hald.: long-horned beetle	A	?	Normal	—	Legs	1		*24,660*
	Saperda vestita: long-horned beetle	A	?	Normal	—	Legs	1		*22,830*
	Diabrotica vittata Fab.: Striped cucumber beetle	A	♂, ♀	Normal	+	Legs	11	23,825–38,550	*30,656 ± 4,711*
	D. duodecimpunctata (Fab.): spotted cucumber beetle	A	♂, ♀	Normal	+	Legs	14	22,139–37,410	*29,491 ± 4,702*
	Lixus mucidus Lec.: snout-beetle	A	?	Normal	—	Legs	2	2,444– 3,333	*2,889*
LEPIDOPTERA	*Neleucania albilinea* Hubner: wheat-head army worm	L	♂, ♀	Normal	+	Legs	4	124,493–155,820	*139,030*
	" " " "	L	?	Bacteria in hemolymph	+	Legs	1		*240,248*
	Protoparce sexta Johans.: tomato-worm	L	♂, ♀	Normal	+	Legs	9	5,212–11,300	*8,119*
	P. quinquemaculata Haworth: tobacco-worm	L	?	Normal	+	Legs	2	5,295– 9,525	*7,410*
	Lycophotia margaritosa saucia Hubner: variegated cutworm	L	?	Normal	+	Legs	2	61,500–70,500	*66,000*
	Heliothis obsoleta Fab.: corn-ear worm	L	♂, ♀	Normal	+	Legs	14	14,340–27,765	*20,690 ± 4,266*
	" " "	L	♂, ♀	Bacteria in hemolymph	+	Legs	6	35,260–42,900	39,513
	Geometridae: measuring worm	L	♂, ♀	Normal	+	Legs	5	58,913–69,578	*64,959*
	Samia cecropia L.: giant silkworm	P	?	Normal	—	Body wall puncture	4	495–616	*564*
HYMENOPTERA	*Neodiprion lecontei* Fitch: LeConte's pine sawfly	L	♂, ♀	Normal	+ —	Legs	17	11,355–40,300	*26,633 ± 7,842*
	" " "	L	♂, ♀	Bacteria in hemolymph	+ —	Legs	4	45,820–46,680	46,150

DISCUSSION

The data included in Table I require to be augmented by future investigations but nevertheless suggest several features that may be of use or interest to comparative physiologists and entomologists.

1. *Range of total hemolymph cell counts:* Of those species of which ten or more individuals were used, two are represented by counts from both larvae and adults. The range is from 2,119 (an imago) to 40,823 (a larva) in 60 individuals of *Chrysopa sp?*, a Neuropteran, and from 8,140 (an imago) to 92,598 (a larva) in 19 individuals of *Phyllophaga sp?* No. 1, a Coleopteran. This is slightly less than the greatest ranges previously found for certain heterometabolous Orthoptera, Odonata, Hemiptera and Homoptera (the authors, 1934, 1935). The range of imaginal counts is from 23,825 to 38,550 for 11 individuals of *Diabrotica vittata* and from 22,139 to 37,410 for 14 *D. duodecimpunctata*. The range of larval counts is from 11,355 to 40,300 for 17 *Neodiprion lecontei* and from 14,340 to 27,765 for 14 *Heliothis obsoleta*. If these data be used as an index, it would appear that the range of counts from larvae or from adults alone would be less than the range of counts for the species.

2. *Comparison of counts from male and female insects of the same species:* The data of Table I permit of comparisons of male and female counts in two species. In two *Alaus oculatus* the average male and female counts are 8,820 and 9,825; in two *O. eremicola*, they are 16,876 and 28,432 respectively. Although these differences are of doubtful significance, they are in agreement with previous observations (the authors, 1934, 1935) that in certain heterometabolous species the female total hemolymph cell count tends to exceed the male count.

3. *Developmental differences in certain Neuroptera and Coleoptera:* The average imaginal and average larval counts are respectively 2,533 ± 245 and 37,681 ± 1,984 cells per mm^3 hemolymph in *Chrysopa sp?* (0.067); 10,090 ± 948 and 56,856 ± 16,952 in *Phyllophaga sp?* No. 1, (0.175); and 22,654 and 33,493 in *O. eremicola* (0.676). Standard deviations are given with the means of larger groups. The figure in parenthesis is obtained by division of imaginal by larval count; thus, in *O. eremicola*, the imaginal count is only 6.76 percent of the larval count. This is a condition opposite to that previously found by the authors (1934, 1935) in certain heterometabolous species, in which the imaginal count was found to equal or exceed the corresponding nymphal count.

No figures are available for imaginal Lepidoptera or Hymenoptera but microscopic observations of minute hemolymph samples from butterflies, moths, wasps, etc., have shown the presence of relatively few hymolymph cells. It is probable that, in these orders, average larval counts are significantly greater than average imaginal counts from a given species.

The four pupal counts obtained are surprisingly low, with an average of only 564 cells per mm^3 hemolymph.

4. *Theoretical significance of developmental differences in total hemolymph cell counts:* It is recognized (Snodgrass, 1930) that the larva possesses a set of well developed larval tissues and organs and, at the same time, a set of undeveloped embryonic tissues or "imaginal discs";

that during metamorphosis (in the pupa) the larval structures are eliminated; and that the imaginal tissues and organs are formed partly from the imaginal discs and partly by a transformation or remodeling of the pre-existing larval organs. May not this series of changes apply not only to the insect's organs and tissues but also to the animal's body fluid which, like vertebrate blood, may be considered a sort of fluid tissue, having a definite structure as have other tissues? If so, a larva-possessing species may be considered to develop during its life history, two different body fluids: a larval hemolymph, characterized by a relatively high total hemolymph cell count, and an imaginal hemolymph, having a somewhat lower total cell count. Furthermore, it may be expected that the larval and imaginal hemolymphs would differ also in the types of cells contained in each, as well as in certain components of the respective plasmas.

TABLE II

COMPARISON OF TOTAL HEMOLYMPH CELL COUNTS FROM NORMAL INSECTS, AND FROM INSECTS IN CERTAIN PHYSIOLOGICAL AND PATHOLOGICAL CONDITIONS

Scientific and Common Names	Average Normal Count ± σ	Count to be Compared	Condition
Photinus sp.?:			
fire-fly (A, ♂)	15,665	28,163 (A, ♂)	Bacteria in hemolymph
" "	"	26,655 (A, ♀)	" "
Phyllophaga sp.? No. 1:			
May-beetle (L, ?)	56,856 ± 16,952	112,995 (L, ?)	Bacteria in hemolymph
" "	" "	106,665 (L, ?)	" "
" "	" "	102,578 (L, ?)	" "
Neleucania albilinea:			
wheat-head army worm, (L, ♂, ♀)	139,030	240,248 (L, ?)	Bacteria in hemolymph
Heliothis obsoleta:			
corn earworm (L, ♂, ♀)	20,690 ± 4,266	42,900 (L, ?)	Bacteria in hemolymph
" "	" "	42,000 (L, ?)	" "
" "	" "	39,920 (L, ?)	" "
" "	" "	39,720 (L, ?)	" "
" "	" "	37,280 (L, ?)	" "
" "	" "	35,260 (L, ?)	" "
Neodiprion lecontei:			
pine sawfly (L, ♂, ♀)	28,633 ± 7,842	46,680 (L, ?)	Bacteria in hemolymph
" "	" "	46,200 (L, ?)	" "
" "	" "	45,900 (L, ?)	" "
" "	" "	45,820 (L, ?)	" "

The nymph-possessing species, on the other hand, may be expected to possess during its life history only one (imaginal) hemolymph. The nymphal and imaginal hemolymphs would then be expected to contain essentially the same plasma components and cell types and to possess essentially the same structural characteristics, differing largely in the total hemolymph cell count which, if it be considered to increase with age, would be expected to have a greater value in the adult than in the nymph.

The total count values presented here and elsewhere by the authors tend to support this view, for in most species from which sufficient data have been obtained nymphal counts have been exceeded by imaginal counts and larval counts appear to exceed imaginal counts.

The investigations of Hollande (1907–1930), as well as others, indicate that cell types differ more markedly from larva to adult than from nymph to adult, and the same has been noted by us. Few data are at hand regarding hemolymph plasma and it would be of interest from this standpoint to make a comparative study of the chemical and physicochemical composition of various insect hemolymphs.

5. *High counts associated with special conditions in the insect:* The authors have suggested elsewhere (1934, 1935) that certain physiological and pathological states of the insect such as parasitism, oviposition (or carrying ootheca) and ecdysis may be associated with excessively high total hemolymph cell counts. The results of the present study are in agreement with that suggestion. Values for the average normal count and for the count of affected individuals of the same species are given in Table II.

In each case the affected individual's count is considerably greater than the average count for the species and, in the larger groups, for which standard deviations are given, differs significantly from the species mean.

6. *Use of anticoagulants:* See the authors (1934) for a discussion of the use of anticoagulant procedures.

SUMMARY AND CONCLUSIONS

1. Average total hemolymph cell counts from 237 individuals of 29 different species representing 4 orders of insects have been determined.

2. In these species, average larval counts tend to be greater than the corresponding average imaginal counts; a relationship opposite to the nymph-imago relationship previously reported.

3. The suggestion is made that the nymph-possessing species develops one hemolymph during its life history while the larva-possessing species may develop during its life history two hemolymphs, a larval and an imaginal hemolymph, differing in total cell count, cell types and plasma composition.

4. Excessively high total counts are found associated with special physiological or pathological conditions in the insect, as were found previously in various heterometabolous species.

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A BIOMETRICAL STUDY OF TWO MORPHOLOGICALLY SIMILAR SPECIES OF TRICHOGRAMMA[1]

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The existence of at least two morphologically similar species or strains of *Trichogramma* was first established by Peterson (6) while he was studying *Trichogramma minutum* Riley as an egg parasite of the oriental fruit moth, *Grapholitha molesta* Busck, and the codling moth, *Carpocapsa pomonella* Linn., in New Jersey. He observed that two forms or species were present that could not be differentiated on a morphological basis. Cross-breeding tests demonstrated that they would not interbreed. A difference in the color of the females of the two species was noted. There was also noted a difference in the flight habits of the two forms, and in the time required for development from egg to adult.

Physiological differences may be an important consideration in the utilization of *Trichogramma* in biological control work. It is the intention of this paper to present a comparison of the productivity, longevity, and developmental period of two structurally similar species when both are subjected to similar environmental (experimental) conditions.

MATERIALS AND METHODS

The forms of *Trichogramma* used were as follows: One, a species from Massachusetts, in which the general color of the females is light yellow, and the males a dark olivaceous brown; the other a species from Louisiana in which the general coloration of both the males and the females is a dark olivaceous brown. Both species have been bred through many generations in the laboratory using eggs of the bagworm, *Thyridopteryx ephemeraeformis* Haw., as host material. Because of the many generations passed through there has undoubtedly been considerable inbreeding.

The breeding containers used in all instances consisted of small cylindrical shell vials (2″ x ½″). Each vial was stoppered with a cork, in the small end of which a fresh seedless raisin on a pin was placed and inserted within the vial. The vials were kept at temperatures existing in the laboratory (75°—80° F.). They were examined

[1]The work embodied in this paper was done while the writer was registered in the graduate school of Ohio State University. Acknowledgment is made to Dr. Alvah Peterson for advisory assistance during the progress of the work.

daily and the raisin in each was moistened with water at the time of examination. This tended to maintain a relatively favorable humidity.

The indications are that more than one generation of *Trichogramma* may develop on the same host eggs, therefore, females used in the productivity tests, were removed from the stock vials soon after they had emerged. Productivity records are of individual, fertilized females isolated in a vial with 97 ± 8 bagworm eggs. The productivity of

TABLE I

SUMMARY OF COMPARATIVE DATA ON MASSACHUSETTS AND LOUISIANA SPECIES OF TRICHOGRAMMA

N—Number of observations; R—Range of variability; M—Mean; S. D.—Standard deviation; C. V.—Coefficient of variability.

Character		Massachusetts Species	Mean diff. and Ratio, $r = \frac{\text{diff.}}{\sigma \text{ diff.}}$	Louisiana Species
Developmental period (days)	N	781		820
	R	10–16		10–18
	M	11.800 ± 0.042[3]	0.472 ± 0.062	12.272 ± 0.045
	S.D.	1.179 ± 0.030	r = 7.61	1.298 ± 0.032
	C.V.	9.993 ± 0.255		10.576 ± 0.264
Productivity	N	49		42
	R	3–143		12–67
	M	62.08 ± 4.01	25.08 ± 4.53	37.00 ± 2.10
	S.D.	27.76 ± 2.83	r ± 5.54	13.48 ± 1.49
	C.V.	44.72 ± 5.40		36.42 ± 4.52
Longevity of productive females (days)	N	49		42
	R	1–18		1–10
	M	5.82 ± 0.52	0.65 ± 0.59	5.17 ± 0.29
	S.D.	3.57 ± 0.36	r = 1.10	1.86 ± 0.20
	C.V.	61.42 ± 8.30		36.06 ± 4.47
Longevity of males (days)	N	57		58
	R	1–15		1–8
	M	5.63 ± 0.44	1.82 ± 0.48	3.81 ± 0.19
	S.D.	3.31 ± 0.31	r = 3.79	1.45 ± 0.14
	C.V.	58.72 ± 7.21		38.21 ± 4.07

[3]Standard error.

each female is based upon the number of adult progeny emerging in the respective vials. Longevity records were taken on these same females.

Longevity of the males was determined by placing lots of five newly emerged males in separate vials. The vials were examined daily and records were made of those that had died.

Developmental period was determined by subjecting bagworm eggs to several females for a period of one hour. The parasitized eggs turn dark a few hours after the parasite oviposits in them. These

were separated from the unparasitized eggs, placed in vials, and examined at the same hour (9:00 A. M.) daily. The adults that emerged on succeeding dates were counted and removed, the time required for development being tabulated.

Obviously, there must be introduced no extraneous source of differentiation between the two species through rearing under different environmental influences or using individuals of different age. All comparative studies were made with individuals of the same age that emerged on the same date. They were conducted in containers placed side by side in the laboratory. Bagworm eggs collected in the vicinity of Columbus, Ohio and stored under refrigeration served as host material.

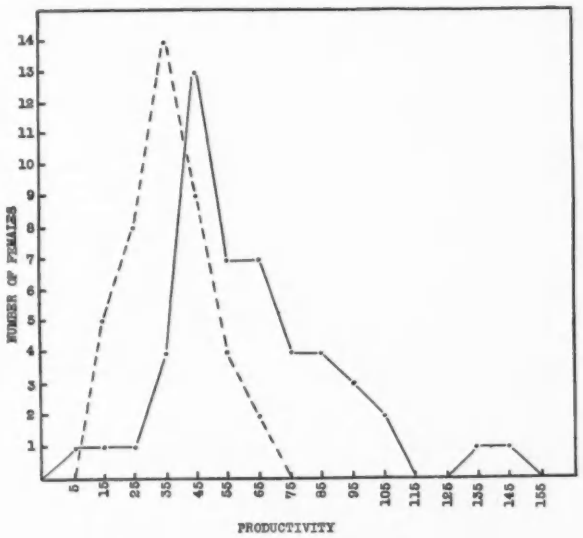

Fig. 1. Showing relative productivity. Only productive females included. Continuous line represents the Massachusetts species; broken line represents the Louisiana species.

In the analysis of the data well-known statistical methods have been employed. Particular reference is made to the work of Fisher (1).

RESULTS

A summary of the comparative data on productivity, longevity, and developmental period of the Massachusetts and Louisiana species of *Trichogramma* appears in Table I.

Productivity: Relative productivity is based upon records of productive females only. The comparative results show clearly that the Massachusetts species is decidely more prolific than the Louisiana

species when reared in bagworm eggs. The average difference is 25.08 ± 4.53 individuals, the productivity of the Massachusetts species exceeding that of the Louisiana species by 67.8 percent. The difference is 5.5 times greater than its standard error and is without reasonable doubt significant.[2] The variation curves, Figure 1, illustrate the greater productivity of the Massachusetts species.

The disparity in productivity is more marked if all females experimented with are considered. Records were obtained on 56 Louisiana females of which 14 were nonproductive. Of 50 Massachusetts females one was nonproductive. The mean number of progeny per Massachusetts female is 60.84 ± 4.12 as compared with 27.75 ± 2.68 for the

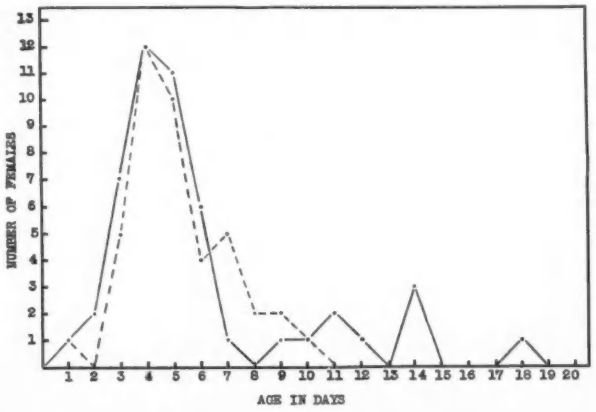

Fig. 2. Showing relative longevity of the productive females. Continuous line represents the Massachusetts species; broken line represents the Louisiana species.

Louisiana females. The average difference is 33.09 ± 4.91, or the Massachusetts species exceeds the Louisiana species by 119 percent when nonproductive females are included in the means.

None of the bagworm eggs in the vials containing nonproductive females turned dark indicating that they had not been punctured by the parasite's ovipositor. Nonproductive individuals were examined under a binocular microscope to make certain that they were females.

Longevity of Productive Females: Reference to Table I indicates that there is no certain evidence of a difference in longevity between the productive females of the two species. Such a difference as appeared may have been due to the errors of random sampling and from the data at hand cannot be regarded significant.

Although there is no significant difference in mean longevity, it is to be noted that the Massachusetts species is represented by

[2]A statistical constant is regarded as being reasonably significant if its value be at least 2 to 2.5 times greater than its standard error.

the longest lived females (see Figure 2). Moreover, the Massachusetts females are absolutely and relatively more variable in longevity than the Louisiana females as is indicated by the standard deviations, and coefficients of variability, respectively.

Longevity of the Males: The males of the Massachusetts species are longer lived and more variable in longevity than the males of the Louisiana species. The mean difference in longevity is 3.79 times as large as its standard error and is considered statistically significant. A comparison of longevity in the males is graphically portrayed in Figure 3. The shorter duration of life in the Louisiana males is apparently correlated with greater activity.

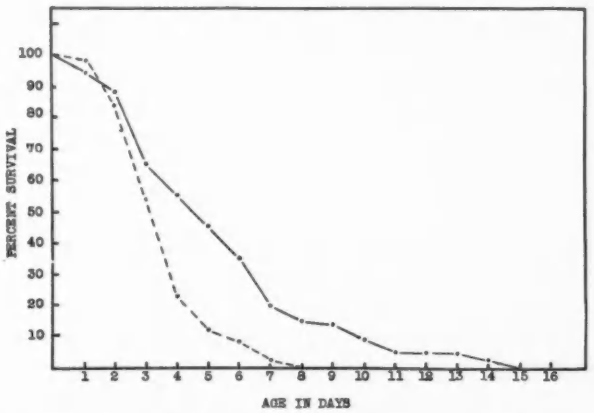

Fig. 3. Showing relative longevity of the males. Continuous line represents the Massachusetts species; broken line represents the Louisiana species.

Developmental Period: Developmental period refers to the time elapsing between egg deposition and the emergence of the adult parasite from the host egg. The Massachusetts species has a shorter mean developmental period than the Louisiana species. The magnitude of the difference, 0.472 ± 0.062 of a day, though small is 7.61 times greater than its standard error. Therefore, the conclusion that the Massachusetts species is characterized by a real and significantly shorter mean developmental period than the Louisiana species seems entirely valid. Figure 4 illustrates this conclusion. The variation curves showing developmental period in the two species plainly represent two distinct populations.

Cross-breeding Tests: The following experiments demonstrate that the Massachusetts and Louisiana species are not interfertile. Twenty-five virgin females of each species were enclosed in a vial with 50 males of the opposite species. The sexes from opposite sources were kept together for approximately one-half day to allow ample time for copulation. Lots of one to four females together with males of the opposite

species were then placed in vials containing bagworm eggs. Copulation between males and females of opposite species was observed, but in all cases the resultant progeny were males, indicating that no fertilization had occurred. In check experiments using males and females of the same species the progeny always consisted of both males and females. Virgin females of both species produced males only.

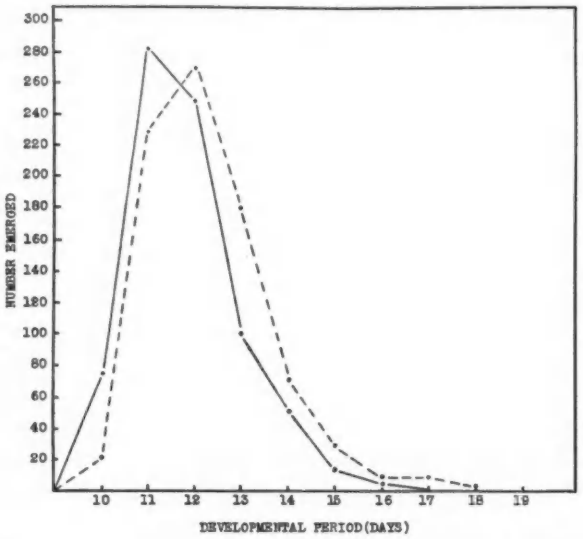

Fig. 4. Showing relative developmental period. Continuous line represents the Massachusetts species; broken line represents the Louisiana species.

SUMMARY AND CONCLUSIONS

The results of this study show that the two species of *Trichogramma* under consideration have statistically significant differences in productivity, longevity, and developmental period. Cross-breeding tests demonstrate that they are not interfertile.

Since both species were at the same time reared under the same conditions. the differences noted are believed to be hereditary. Shorter developmental period, greater productivity of the females, and longer duration of life in the males might be regarded as constitutive elements in the make-up of the Massachusetts species differentiating it from the Louisiana species, just as certain morphological characters distinguish *Trichogramma minutum* from other recognized species of the genus *Tricho-*

gramma. That these differences will not apply in distinguishing an individual of either species from the other is apparent, because of the pronounced intergradation of the characters. This is obvious from a glance at the various charts. However, it is evident that these two physiological species have characteristic differences when each is considered as a group or population.

The case presented by these two species instances the value of quantitative studies in certain types of taxonomic work. With respect to the characters studied variation in the two forms is decidedly transgressive. Consequently, statistical methods are invaluable in defining differences between them.

It is interesting to note that under the conditions of this study, the Massachusetts species exhibits greater variability than the Louisiana species in all the characters studied except developmental period. This may be of considerable significance, in that a physiologically variable species would probably prove adaptable to a wider range of environmental conditions, than would a less variable species.

Peterson (8) in a recent investigation of two forms of *Trichogramma* from New York, obtained results on productivity, and longevity that depart widely from those of the present study. Flanders (3), (4), distinguishes five races on the basis of differences in developmental period and the color of the females. These suggest that a critical study of *Trichogramma* from various parts of the country would disclose the presence of many physiological species.

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EPIGOMPHUS CREPIDUS A NEW DRAGONFLY (ODONATA: GOMPHIDAE) FROM NAYARIT, MEXICO WITH NOTES ON THE GENUS

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Ohio State University, Columbus, Ohio

The specimens (5 ♂♂, 1 ♀) of the new species of Epigomphus came to the writer in a small collection of Odonata purchased from Ward's Natural Science Establishment, Rochester, New York. These were from Victoria Compostela, Nayarit on the west coast of Mexico and had been collected in July and August, 1934, by two of Ward's field men.

Because this species appears to be less specialized in the male abdominal appendages than any of the males described we have illustrated the species rather generously and have included figures of two other species of which material was available. We wish to thank Mrs. L. K. Gloyd for the loan of specimens of *Epigomphus subobtusus* Selys, from the Williamson Collection.

Epigomphus crepidus n. sp.

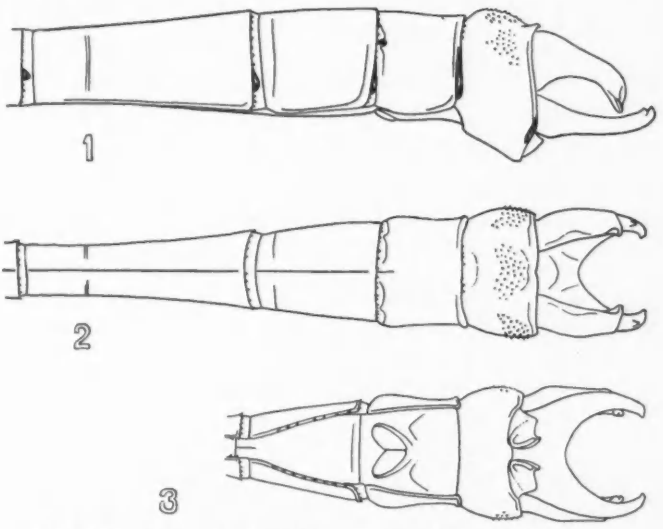
A dark brownish-black species with narrow olive green or yellowish stripes on face and thorax. Base of abdomen pale on sides with segment seven largely pale.

Length of abdomen, including appendages, male, 37.5–41 mm., female, 40 mm.; of hindwing, male, 33–34 mm., female, 36 mm.

MALE, HOLOTYPE:

Head.—Labrum broadly edged with black below, a pale olive green spot on either side, between these a broad vertical bar of brown. (Fig. 15.) Anteclypeus brown, postclypeus darker brown, narrowly edged on sides and below with pale except along middle third of lower edge. Frons clear pale-olive above, edged behind with black, dark brown on vertical surfaces. Vertex dark brown with a pale line encircling each ocellus and a minute olive triangle posterior to each lateral ocellus. Occiput brown with middle third of posterior edge pale. Genae and bases of mandibles olive. Rear of head dark brown above and about occipital foramen, shading into olive on outer and ventral areas. Prothorax (fig. 21) with posterior lobes olive, in front of which two pale spots on middle lobe; outer ends of middle lobe pale; anterior lobe narrowly edged with pale.

Synthorax dark velvety brown (blackish) above, pale olive on lower sides, coxae and ventral surface. Antealar sinus with four pale dots, one at either end of either half. Mesepisternum dark brown with two vertical stripes, that next the middorsal keel a straight bar with parallel sides and rounded ends, one-seventh as wide as the sclerite, the bars of the two mesepisterna divergent below. The second or antehumeral stripe a mere thread in width, angled (obtusely) at its upper third with its upper end as wide as the anterior stripe. The transverse mesostigmatal keel followed by an olive band as wide as the wider of the mesepisternal stripes, broken in the middle by the middorsal keel.

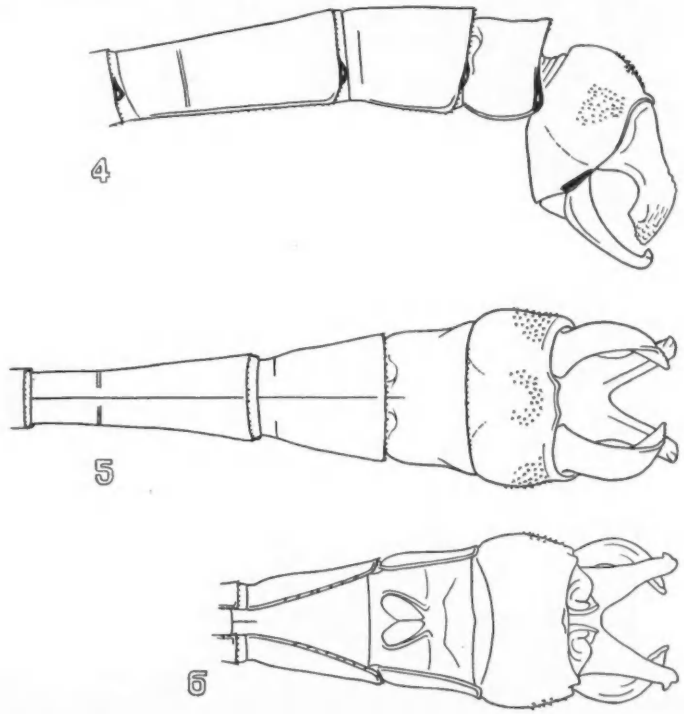


FIGS. 1–3. *Epigomphus crepidus*, n. sp., male, apex of abdomen. Drawn from holotype.

Mesepimeron dark brown, its rounded lower end pale, with an olive stripe one-third as wide as the sclerite, slightly narrower above, then widening caudad along the alar carina. Metepisternum dark brown above, its lower third olive, which color is continued dorsad to the alar carina as a broad stripe with sinuate sides, a narrow neck and rounded head at its upper end. Second lateral suture narrowly edged with dark brown from infra-episternum to alar carina, metepimeron otherwise olive except for an obscure pale brown area on center line of its lower half. Legs with coxae, trochanters and femora pale; apex of latter black and anterior surface of first femur black; tibia and tarsus black. Wings hyaline with stigmas and veins black.

Abdomen, segment 1, olive with posterior edge of side black. Seg. 2, olive on side, black above and on side down to auricle, a black apical ring. Seg. 3 with upper third of side, dorsum and apical ring black

but middorsal keel yellow. Segs. 4–6 similar but with the black on the apex more extensive on each succeeding segment until in seg. 6 the whole apical end of the side is black; the yellow dorsal keel fading out entirely on seg. 6. Seg. 7 with basal two-thirds entirely yellow (?), its apical third black except for yellow middorsal keel, lower edge of side narrowly yellow and a narrow yellow stripe on middle of side continuing from the yellow base to the apical ring. Apical ring yellow above, black on



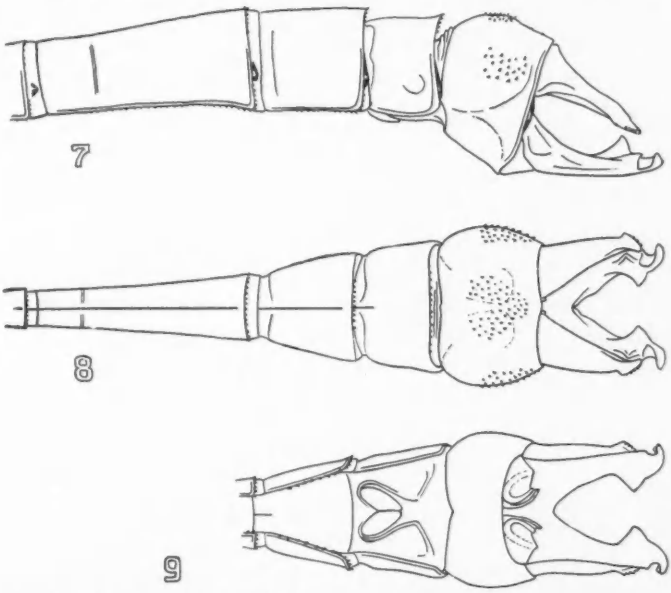
FIGS. 4–6. *Epigomphus subotusus* Selys, male, apex of abdomen. From a specimen collected by E. B. Williamson, at El Fiscal, Dept. Guatemala, Guatemala, June 4, 1909. In Williamson Collection.

sides. Segs. 8–10 largely blackish but obscurely clouded on sides with paler brown. Appendages dark brown, tipped with black.

Structural Characters.—Superior appendages (figs. 1–3) viewed from above quadrangular with outer apical angle obtuse and inner apical angle acute; viewed from side the tip turns down and the two apical angles appear as blunt teeth, with the inner angle much lower than the outer; viewed from behind, the outer angle is a simple angle, from it the inferior apical edge runs ventrad and entad to the well defined but blunt tooth of the inner apical angle which is directed ventro-entad.

Inferior appendage widely forked, the prongs twice the length of the base, the apical incision viewed from above or below (figs. 2, 3) rounded on its sides and anterior end so that it is almost circular but with the apices of the appendage turned distinctly entad; each apex with two minute teeth, one turned entad, the other (subapical) turned dorsad.

Described from the male holotype in the author's collection. The type is the largest male with abdomen 41 mm. long and hindwing 34 mm. Collected vii, 1934. Nayarit, Mexico.

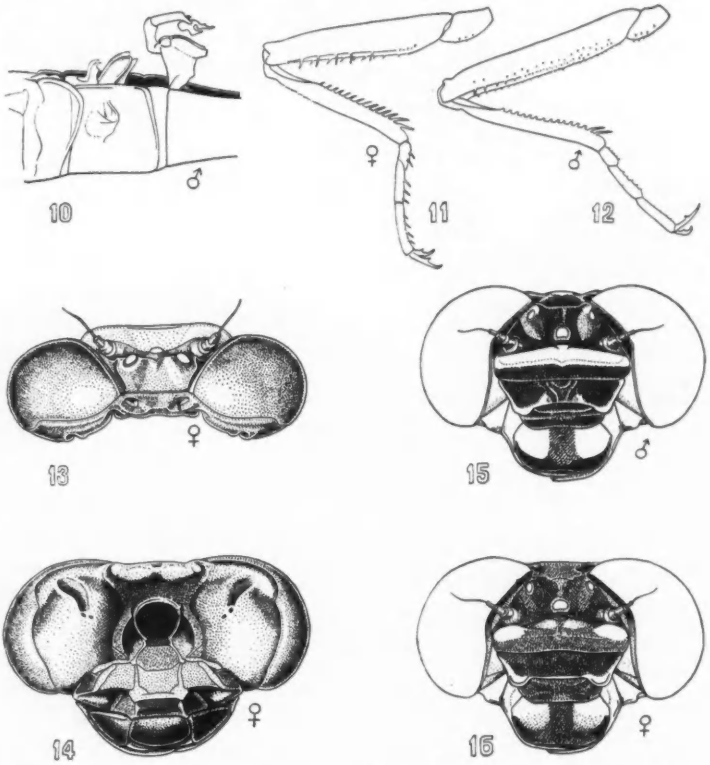


FIGS. 7–9. *Epigomphus obtusus* Selys, male, apex of abdomen. Drawn from one of four males in the author's collection. Collected by Wm. Clarke-Macintyre, near Rio Ilupulin, Rio Jatun Yacu, a head-water of the Rio Napo, Prov. Oriente, Ecuador, January, 1935.

The four other paratype males differ little from the holotype. Two have the narrow antehumeral stripe as described, two have this stripe absent and represented by only its dilated upper end, a triangular spot with rounded angles.

The appendages of the second and third segments of the male abdomen are shown in figure 10. The anterior or first hamules, when viewed at a certain angle from below, appear to have a broad, low subapical hook on the posterior edge pointed entad. This is not such a hook when viewed otherwise but

merely the inturned edge at the posterior shoulder just above the terminal hook. The ligula has on either side of its base a narrow dorsad pointing spine with bifurcate apex as shown by Calvert for *subsimilis* (1920, pl. 13, fig. 4).



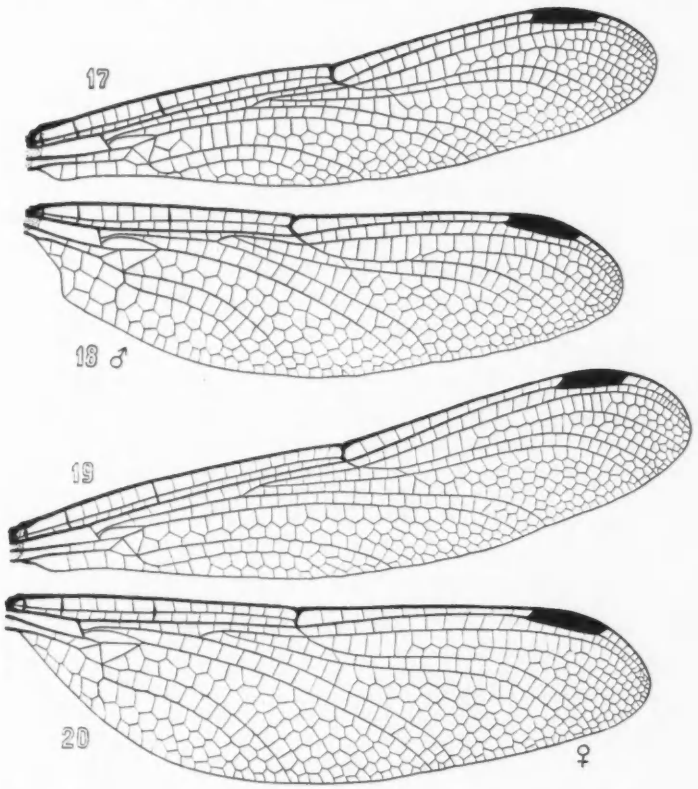
FIGS 10–16. *Epigomphus crepidus*, n. sp. 10. Second segment of male abdomen, from paratype male. 11. Metathoracic leg of female allotype. 12. Metathoracic leg of male paratype. 13 and 14. Head of female allotype, showing pits and other adaptations to the male's claspers. 15. Color pattern of face, male holotype. 16. Color pattern of face, female allotype.

FEMALE, ALLOTYPE:

Head.—Color as in the male but pattern slightly less sharply defined. Color of head (fig. 16) as in the male but brown replacing black on the middle area of the lower edge of the labrum. Dorsal surface of frons with median two-fourths brown which reduces the olive of this area to an oval spot at either side. Brown areas of rear of head paler than in male.

Thorax colored as in the male (fig. 22) but brown less intensely dark and edges of lateral pale stripes less sharply defined, this character not well shown in figure 22.

Abdomen with color of segs. 1 and 2 as in the male but with a broad brown stripe along lower half of seg. 2. This continued along lower



FIGS. 17–20. *Epigomphus crepidus*, n. sp. 17 and 18. Wings of a male paratype. 19 and 20. Wings of the female allotype. Notice the costal cross vein in extreme base of wing which is usually overlooked when present.

edge of segs. 3–7, its middle upper edge fusing along its middle third with the dorsal black on the sides of segs. 5 and 6, which segments are black with an anterior and a posterior lateral spot each. Seg. 7 with the lower third of its side black but narrowly edged below this with yellow, above this black bar the basal half of segment yellow, the apical half black. Segs. 8–10 clouded with paler brown areas on sides. Appendages black.

Structural Characters.—The apical segments of the abdomen and appendages of the female are shown in figures 23 and 24. The notch of the vulva narrow and acute. The epiproct (median dorsal appendage) as long as the cerci and in side view (fig. 23) notched at the tip. The paraprocts each with an illy defined Y-shaped ridge on the outer side.

This specimen had the apex of the abdomen badly flattened laterally. The restored shape of the segments in figures 23 and 24 may not be quite right for the living female. In this mashed specimen the sternite of segment 10 and the two paraprocts bulge ventrad. The hind leg of the female is shown in figure 11, (of the male in fig. 12). The mating adaptations, pits, etc., of the female's head are shown in figures 13 and 14.

Described from allotype female from Nayarit, Mexico, taken vii, 1934. In the author's collection.

The name *crepidus* refers to the assumption that this species may be a fundamental type in the phylogeny of the genus.

VENATIONAL NOTES:

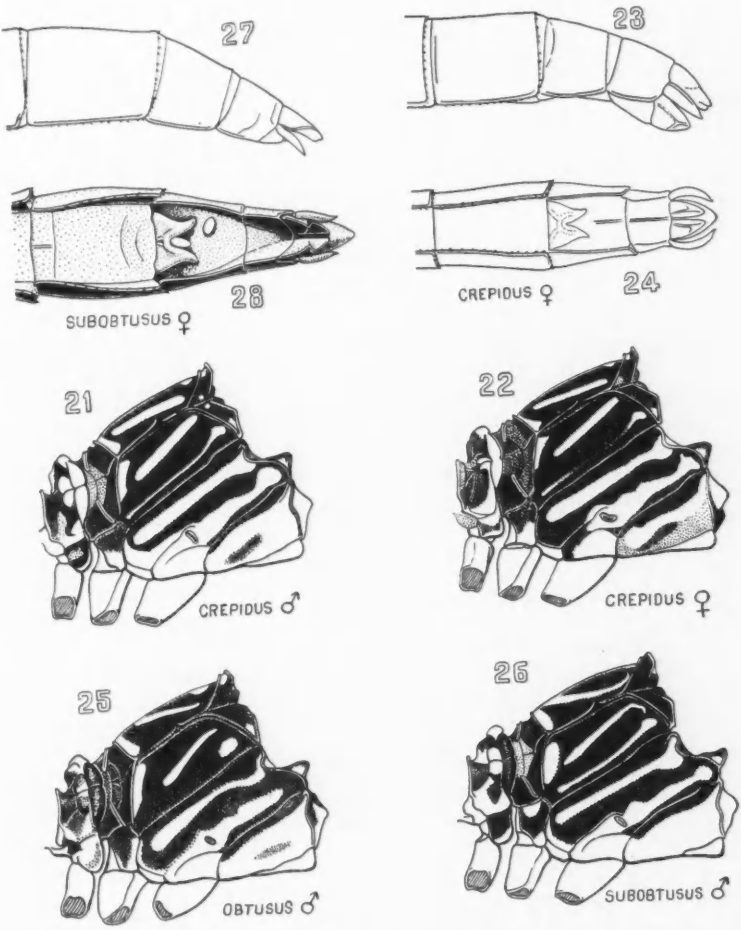
Figures 17 and 18 are from paratype male No. 4 which has 5 single cells in base of M_4 space in left fore-wing. (The drawings were made by projector and show under side of the left wings.) Male No. 3 has 2 single cells on left and 4 on right in this area. All other specimens with 2 complete rows of cells in M_4 space in fore-wings. M_4 space with 2 complete rows in hind-wings of all specimens.

The holotype male has triangle of right hind-wing crossed and that of left hind-wing with a stub-vein on either side; all other specimens with all triangles free. Holotype male with: bridge crossveins f. wgs. 6, 8, h. wgs. 6, 6; antenodals f. wgs. 17, 18, h. wgs. 11, 12; postnodals f. wgs. 11, 12, h. wgs. 11, 10; number of weak veins between the two strong antenodals f. wgs. 4, 5, h. wgs. 3, 4.

Figures 17–20 show a hidden (from above) humeral (?) crossvein in the extreme base of the costal and subcostal spaces which is not considered in the previous antenodal counts.

The allotype female with: bridge crossveins f. wgs. 6, 8, h. wgs. 6, 6; antenodals f. wgs. 17, 18, h. wgs. 13, 14; postnodals of f. wgs. 11, 12, h. wgs. 10, 10; weak veins between the two strong antenodals f. wgs. 4, 5, h. wgs. 5, 4.

Variation in the four paratype makes (Nos. 1–4): bridge crossveins usually f. wgs. 7, 7, h. wgs. 6, 6 but right f. wg. (No. 2) 8, left h. wg. (No. 1) 7, right h. wg. (No. 4) 5 bridge crossveins; antenodals in f. wgs. vary from 14 to 19, the average 16.25, 16.5; antenodals in h. wgs. vary from 10 to 13, the average 12, 11.25. Postnodals in f. wgs. vary from 10 to 13, the average 11, 10.75; in h. wgs. 10 to 12, the average 10.75, 11. The number of weak veins between the two strong antenodals varies, f. wgs. from 3 to 6, in h. wgs. from 3 to 4, averages are f. wgs. 4.25, for h. wgs. 3.75.



FIGS. 21–24. *Epigomphus crepidus*, n. sp. 21. Color pattern of thorax of male holotype. 22. Of female allotype. 23–24. Apex of female abdomen. Ventral surfaces of segs. 9 and 10 probably everted by mashing. Seg. 10 probably too wide in fig. 24.

FIG. 25. *Epigomphus obtusus* Selys. Color pattern of thorax of male, Rio Jatun Yacu, Ecuador, Jan., 1935. In author's collection.

FIGS. 26–28. *Epigomphus subobtusus* Selys. 26. Color pattern of thorax of male, El Fiscal, Guatemala, June 4, 1909. 27–28. Apex of abdomen of female. Collected by E. B. Williamson, P. Barrios, Guatemala, June 23, 1909. In Williamson Collection. Two eggs attached to the specimen are shown. Notice the concavity or fossa on ventral surface of seg. 10, fig. 28. The specimen appears to be in an excellent state of preservation.

GENERAL NOTES

This genus is now known from twelve species which are spread from central Mexico to Sao Paulo and Matto Grosso in Brazil and to Bolivia and Ecuador. The described species (except the genotype *paludosus* Hagen (Selys 1854), known from a female only) are very distinct which usually indicates a mature or old genus. Six of the species have been described by Calvert who has an interesting paper (Calvert, 1920) on the mating adaptations of the female's head to the various prongs and teeth of the male's claspers. We show these pits for *crepidus* in figures 13 and 14.

The female is peculiar also in the structure of the apex of the abdomen. The apex is narrow for a female Gomphine and the ventral sides of segments 9 and 10 and the paraprocts are concave or folded in. The single female of *crepidus* having been mashed, does not show this so we have introduced figures 27 and 28 of the female of *subobtusus* Selys, a specimen from the Williamson Collection, University of Michigan, which shows this ventral fossa. Ris (1918, p. 153) suggests that the female may oviposit in a narrow crevice as between the leaves of Bromeliads, but Calvert (1920, p. 330) has a note on *subsimilis* Calvert which indicates that the latter species oviposits in the surface of water as usual for Gomphines.

Some figures of male *obtusus* Selys and male *subobtusus* Selys are introduced for comparison with those of *crepidus*.

THE POSITION OF CREPIDUS IN THE GENUS

Calvert's first key (1903) throws *crepidus* next to *subobtusus*, which appears to be its natural position. Calvert's second key (1920, p. 332) runs the female *crepidus* to *subobtusus*. Ris' key (1918, p. 146) runs *crepidus* out to *subobtusus*. *Crepidus* differs from *subobtusus* in that the tips of the male inferior appendage turn entad. In *subobtusus* ((figs. 4–6) the tips of the inferior appendage turn ectad. *Crepidus* differs further in that the abdominal segment 10 of the male is less enlarged (compare figs. 2 and 5). The superior appendages of *subobtusus* are more arched in both dorsal and lateral views. There are slight differences in the color patterns (compare figs. 21 and 22 with fig. 26).

After examining all the excellent illustrations by Calvert and Ris, we conclude that the male appendages of *crepidus*

are least specialized of these appendages in the ten known males. Close to *crepidus* is *subobtusus* of Costa Rica and Guatemala, but more specialized as stated in the preceding paragraph.

From such generalized stock stems a group composed of *armatus* Ris, *tumefactus* Calv., *quadrices* Calv., *camelas* Calv., and *subsimilis* Calv., all species of which have short heavy (robust) inferior appendages. These are distributed through Central America and Panama.

From the earlier stock of, or related to *crepidus* and *subobtusus* have sprung other species with long slender prongs on the inferior appendage. These are *verticicornis* Calv., a species peculiar in that there is a slender spine at base of either prong of the inferior appendage, *obtusus* Selys peculiar in that each prong of the inferior appendage has an external apical notch filled with stiff curving hairs, and the pair of species *llama* Calvert of Bolivia and *hylaeus* Ris of Matto Grosso. The last two species have very slender appendages.

If the relationships are correctly interpreted, the genus may have originated in southern Mexico and then spread to South America.

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VARIATION AND ATROPHY OF FLYING WINGS OF SOME CARABID BEETLES

(Coleoptera)

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Museum of Comparative Zoölogy, Cambridge, Mass.

This paper begins (Part I) with a description of the morphology of the inner or flying wings of the beetles of the family Carabidae (predaceous ground beetles) of eastern North America. It then (Part II) discusses the state of the wings in connection with the behavior and habitat of the insects, and (Part III) attempts to discover how the atrophy of the wings of the flightless species has occurred. Accumulation of data was begun during the winter of 1930–31. Since then I have had for examination, chiefly from the Museum of Comparative Zoölogy and my own collection, specimens of practically every species of Carabid known from eastern North America, and considerable series of the more interesting ones.

I am indebted to Prof. W. M. Wheeler, Prof. C. T. Brues, Prof. Nathan Banks, and Dr. F. M. Carpenter for information and suggestions on a number of points, to Mr. A. J. Mutchler and Mr. C. A. Frost for loan of specimens or information about various American Carabidae, to Mr. Carl H. Lindroth for information about some northern European species, and to Dr. G. D. Snell for passing upon the genetics of the paper. I have been aided, too, by facilities put at my disposal in the entomological section of the Biological Laboratories, Harvard University.

METHODS

Little need be said about the technique of examining the inner wings of Carabidae. If the state of the wings cannot otherwise be determined in a dried museum specimen, the specimen is easily relaxed and an elytron raised or removed to expose the inner wing.

This paper refers continually to the Carabidae of "eastern North America." This region may be defined, for present purposes, as eastern Canada and the states lying in, east of, or (toward the west) adjacent to the Appalachian mountain system. These states are those of New England, New York, Pennsylvania, New Jersey, Maryland, West Virginia, Virginia, Kentucky, Tennessee, North and South Carolina, Georgia, Alabama, and Florida.

The nomenclature and sequence of species of Leng's Catalogue of Coleoptera of America north of Mexico (1920) have been followed except that it has unfortunately been impossible to identify some of the species described by T. L. Casey. Forbes (1922) has been taken as standard in naming wing veins, although some of his interpretations differ from those of other authors, and Snodgrass (1909) has been followed in identifying and naming the parts of the metathorax.

My drawings have been made from camera-lucida outlines. Emphasis has been placed upon the relation of the wing or its vestige to the whole insect rather than on the microscopic structure of the wing, so the vestigial wings have been drawn *in situ*, with no more detail than is there visible. The functional wings, however, have been spread and mounted on slides. They cannot be properly examined otherwise. It has been found best to mount the wings dry, under ringed cover glasses, for the unstained membrane of small wings is practically invisible in ordinary mounting media. All of the specimens figured are now in the Museum of Comparative Zoölogy.

Part I. Morphology

When the inner wings of Carabidae degenerate, they sometimes become very small, among the Cychrini (Pl. I, Fig. 5) for example, but the last, minute wing vestiges are nevertheless extraordinarily persistent. In fact I have never seen a Carabid in which the inner wings were entirely lacking, in spite of numerous misleading published references to "apterous" or "wingless" species. Sharp (1903, 179) has remarked that most so-called "apterous" beetles really have vestiges of the inner wings, and Oertel (1924, 40) deals with some published errors in detail, with regard to the genus Carabus. Nevertheless Oertel himself (pp. 40 and 117) follows W. Horn (1907, 464) in stating not only that certain Cicindelidae (close relatives of Carabidae) are completely apterous, but that Anthia is too. As a matter of fact neither Anthia nor the Cicindelidae he mentions are strictly apterous, so far as the material I have examined goes. A specimen of *Anthia sp.* has distinct, vestigial inner wings reaching to the first abdominal spiracles, free, but pressed against the sides of the metanotum so closely that they might easily be overlooked. Among the supposedly apterous genera of Cicindelidae, some of which W. Horn (*l. cit.*) considers primary wingless forms, not reduced, Oertel mentions Omus as lacking even traces of rudiments of the inner wings. In *Omus dejeani* Rche. (Plate I, Fig. 2), however, the inner wing is perfectly distinct, over 1.5 mm. long, but so slender that it is not easily seen. It is placed, too, so that it is likely to be broken off if the elytron is removed without relaxing the insect properly. In *Omus audouini* Rche. the vestigial wing is shorter and more sack-like, and apparently corresponds to the base of the wing vestige of *dejeani*. Amblycheila, also mentioned by Horn (*l. cit.*), is likewise not strictly apterous, at least in *A. cylindriformis* Say (Plate I, Fig. 3) for the inner wings are present as small, sack-like folds lying in depressions at the sides of the metatergum. In *Tricondyla aptera* Ol. (Plate I, Fig. 4), which has the humeri as completely obsolete and the body otherwise as highly modified for a

flightless existence as any adephagous beetle I know, the inner wings (in specimens from the Solomon Islands) have come close to complete atrophy, but even in this insect there remains on each side a small sclerite, fused along its upper side with the metanotum but partly free below, which is like the vestigial wing of Amblycheila in its relation to the parts of the metanotum. I think there can be no doubt that this is the remnant of a flying wing.

Since *Tricondyla aptera* has the inner wings more degenerate than any other Cicindelid or Carabid which I have examined, I have gone to considerable pains to homologize the parts of its metatergum with those of a series of less specialized Cicindelidae, beginning with *Cicindela belfragei* Sallé (Plate I, Fig. 1) in which the wings are vestigial but the metatergum not much distorted, and continuing through *Omus dejeani* and *Amblycheila cylindriformis*, both mentioned above, in which the metatergum is successively more highly modified. Of course this is an arbitrary, not a true phylogenetic series. There is some doubt as to whether the large anterior plate in the figure of Tricondyla is an abnormally dilated mesothoracic postnotum, as labeled (the postnotum of the mesothorax is usually small or absent in beetles), or an equally abnormally dilated metathoracic prescutum. The former seems more probable, for the plate in question lies immediately behind the conspicuous axillary cord of the mesonotum and is separated from the apparent wing vestige by a suture. Except for this anomalous plate, there is little doubt of the homologies in the four species figured. The prescutum in each case is a narrow sclerite at the extreme front of the metatergum. It forms the lateral anterior corner of the notum and is fused with the base of the wing vestige, forming the anterior notal wing process. The postnotum, forming the extreme posterior portion of the tergum, is also easily identified, although it is usually more or less fused with the degenerate notum. It may be recognized, first, because it is limited anteriorly by the remnant of the axillary cord, which can often be traced for at least a short distance from the (metathoracic) scutellum even in degenerate metaterga and, second, because its outer margin coincides with and is attached to the inner face of a definite plate of the episternum (shown by a broken line in the figures) which is pointed or angulate opposite the anterior corner of the postnotum. In functionally winged species this episternal plate is out-flaring and conspicuous. In flightless forms it is present merely as a flat sclerite. Finally, most of the metatergum between the prescutum and postnotum is the scutum. Usually it is plainly divided into anterior and posterior parts by a suture, and the outer edge of the posterior part, the posterior notal wing process, is fused with the vestigial wing.

It will be seen that, as the metatergum atrophies, the postnotum is less affected than the other parts, and makes up a larger and larger proportion of the tergum. This is probably because it is not directly connected with the wings but serves as a supporting arch across the body. Its function is comparatively little changed by wing atrophy.

To return to the Carabidae, I have examined with great care a number of genera in which the humeri are rounded or which are otherwise modified as a secondary result of longstanding wing atrophy

(see p. 151 for the structural changes accompanying or following wing atrophy), but in none of them have the inner wings been as nearly lost or the metathorax as highly modified as in Tricondyla. The genera I have examined include Scaphinotus, Sphaeroderus (Oertel, 1924, 40, says that probably the inner wings are lacking in no genus of Carabes), the *ovipennis* group of Nebria, Pasimachus (Brues, 1908, 47, found wing vestiges in all species examined by him), the *hydropicus* group of Trechus, Anopthalmus (Jeannel, 1926, 332, states that he knows no Trechinae with the inner wings totally absent), several subgenera of Pterostichus in which the elytra are fused together (Maran, 1927, states that none of many Pterostichini he has examined is completely apterous), Dicaelus, and Rhadine. Of course I cannot say that strictly apterous species never occur in these or other genera. I can only repeat what I have said above, that I have not myself examined any species of Carabidae, or of Cicindelidae, in which there were not at least vestiges of the inner wings.

Except that they are apparently never completely absent, the flying wings of Carabidae may show the greatest differences between closely related species, for one species may have functional and its close relative minute, vestigial wings. *Notiophilus aquaticus* (L.) (wings strong) and *N. borealis* Harr. (wings vestigial) are prime examples. Even within single species the wings sometimes, though not usually, are very variable. The variation may be more or less continuous or it may take the form of striking dimorphism. Examples are given in the following pages.

It will be convenient now to draw up, for reference during further discussion of wing atrophy, a list summarizing, by tribes or genera, all the Carabidae of eastern North America. The list is based upon the ranges of species as given in Leng's Catalogue (*l. cit.*) with slight modifications to conform with recent discoveries.

LIST 1

NATIVE CARABIDAE OF EASTERN NORTH AMERICA

Cychrini, 21 species (about)
Carabus, 6
Calosoma, 6
Elaphrini, 10
Loricera, 1
Notiophilus, 6
Pelophila, 2
Nebria, 6
Pasimachus, 6
Other Scaritini, 44 (about)
Panagaeus, 2
Nomius, 1
Morion, 1
Bembidion, 58 (about)
Other Bembidiini, 28 (about)
Micratopus, 2
Patrobus, 4
Platidius, 1
Trechus, 4
Anophthalmus, 8
Diplochaetus, 1
Pterostichini, 88 (about)
Amarini, 28 (about)
Rembus, 4
Dicaelus, 15 (about)
Badister, 8
Platynini, 57 (about)
Anchoderini, 2
Leptotrachelus, 1
Casnonia, 2
Driptini, 7
Ega, 1
Lebiini, 61 (about)
Helluomorpha, 5
Brachinus, 14 (about)
Miscodera, 1
Chlaeniini, 26 (about)
Oodiini, 12
Harpalini, 110 (about)
TOTAL, 660 species

No special discussion of this list is necessary. The following list, however, is more important. In the left hand column are set out as briefly as possible all the Carabidae of eastern North America in which I have found a marked atrophy of the inner wings. Species in which the wings are dimorphic or show extreme variation are indicated. In the right hand column are set down for comparison a few functionally winged species which are closely related to the vestigially winged ones opposite.

LIST 2

NATIVE CARABIDAE OF EASTERN NORTH AMERICA IN WHICH WING ATROPHY HAS BEEN FOUND

VESTIGIALLY WINGED SPECIES	STRONGLY WINGED RELATIVES
Cychrini, 21 species (about)	
Carabus maeander lapelayi Castn. *cham. groenlandicus* Dej. *sylvosus* Say *serratus* Say (dimorphic) *limbatus* Say *vinctus* Web.	
Notiophilus semistriatus Say *borealis* Harr. *novemstriatus* Lec. *nemoralis* Fall	*N. aeneus* Hbst. *aquaticus* (L.)
Pasimachus, 6 species	
Scarites californicus Lec.	*S. subterraneus* Fab. *substriatus* Hald.
Bembidion picipes (Kby.)	All other local species of subgenus Peryphus
Bembidion semicinctum Notman *muscicola* Hayw. (dimorphic)	All other local species of subgenus Notaphus
Amerizus oblongulus (Mann.)	*A. spectabilis* (Mann.)
Anillus fortis Horn	
Lymneops puritanum (Hayw.)	
Tachyura ferruginea (Dej.)	All other local species of Tachyura[1]
Patrobus longicornis (Say) (dimorphic)	
Patrobus tenuis (Lec.)	Two other species of tenuis group in eastern N. A.
Trechus[2] *chalybeus* Dej. *carolinae* Schffr. *hydropicus* Horn	*T. rubens* Fab.
Anophthalmus, 8 species	
Myas, 2 species Gastrellarius, 3 Pterostichus, 2	

[1]Since this was written I have discovered that *Tachyura granaria* (Dej.) has the wings dimorphic.

[2]The number of Trechini will have to be increased to conform with Jeannel's (1931) revision; and of "Anophthalmus," to conform with Valentine (1932)—papers which came to hand after my lists had been compiled.

VESTIGIALLY WINGED SPECIES	STRONGLY WINGED RELATIVES
Cylindrocharis, 2	Piesmus
Anaferonia, 1 (about)	Poecilus
Cyclotrachelus, 6 (about)	Lophoglossus
Eumolops, 4 (about)	Omaseus
Evarthrus, 6 (about)	Dysidius
Monoferonia, 4	Pseudargutor
Perestria, 5 (about)	Bothriopterus
Peronina, 1	Loxandrus
Euferonia, 6 (about)	
Lyperopherus, 1	
Referonia, 2	
Abacidus, 5	
Gastrosticta, 3 (about)	
Cryobius, 3	
Paraferonia, 1	
Micromaseus[3] *patruelis* (Dej.) (dimorphic) *corrusculus* (Lec.) (variable)	
Celia remotestriata Dej. (dimorphic)	All other local species of Celia
Dicaelus, 15 species (about)	
Badister notatus Hald.	All other local species of Badister
Calathus gregarius Dej. *gregarius ingratus* Dej.	*C. opaculus* Lec.
Pristodactyla impunctata (Say)	*P. advena* (Lec.)
Rhadine caudata Lec.	
Platynus hypolithos (Say) *angustatus* Dej. *gracilentus* Beut.	
Platynus trifoveolatus Beut.	All other local species of subgenus Anchomenus
Platynus retractus (Lec.) (dimorphic)	All other local species of subgenus Agonum
Platynus obscurus Hbst.	
Dromius atriceps Lec.	*D. piceus* Dej.
Eucaerus varicornis Lec.	
Cymindis unicolor Kby. *cribricollis* Dej. (dimorphic) *pilosa* Say (dimorphic) *borealis* Lec. (dimorphic) *neglecta* Hald. (dimorphic) *elegans* Lec. (dimorphic) *americana* Dej. (dimorphic)	
Chlaenius platyderus Chd. *aestivus* Say (dimorphic)	All other local species of Chlaenius
Harpalus fulvilabris Mann.	All other local species of subgenus Harpalus, *s. s.*
Harpalus (Ophonus) spadiceus (Dej.) *carolinae* Schffr.	
Acupalpus hydropicus (Lec.)	*A. carus* (Lec.)

[3]Genera from Gastrellarius to Micromaseus, and from Piesmus to Bothriopterus in the winged column, are often considered as subgenera or groups of Pterostichus, *s. lat.*

According to this list there are, in eastern North America, 159 species of native Carabidae in which marked wing atrophy of one sort or another has been found. This is 24.1 percent of the total of 660 species summarized in List 1. Dimorphism or other extreme variation of the wings has been found in the 14 species indicated and probably occurs in others, but can be discovered only by examination of much longer series than I have usually had for dissection. Of the majority of species I have been able to examine not over half a dozen specimens.

List 2 is more than a simple tabulation of the local Carabidae in which wing atrophy has been found. It attempts to show, by transverse dividing lines, the minimum number of groups in which atrophy has occurred *independently*. In making these divisions it has been assumed that, whenever a genus or other natural phylogenetic group contains either a dimorphic species or two species one with functional and the other with vestigial wings, wing atrophy has occurred independently within that genus or group, for the flightless species are more likely to have been derived from the ancestors of their strongly winged relatives than from more distantly related flightless forms. On the whole I think I have been very conservative in dividing the list into as few groups, 32, as I have done, for in Carabus, Notiophilus, the Pterostichini, and some other genera or tribes atrophy may have occured a number of different times. It is safe to say, then, not only that about a quarter of the Carabidae of eastern North America have more or less atrophied wings, but that atrophy has taken place independently at least 32 times.

In order to go beyond these general conclusions it will be necessary to examine and classify the 14 dimorphic or exceptionally variable species in some detail. In grouping individuals of the variable species into classes according to wing length I have chosen as a criterion the position of the wing tip with respect to the sides of the *ventral* abdominal segments, for this can be seen easily from the side with an elytron only a little raised. The dorsal segments of the abdomen are much more difficult to distinguish than the ventral ones, especially with the elytron only slightly raised, and the ratio of wing length to elytral length, which might be used as a measure, cannot be determined accurately without complicated measuring.

1. **Carabus serratus** Say

(Plate I, Figs. 6a, b)

The wings of this species are strictly dimorphic, being either fully developed or reduced to small vestiges. Only two strongly winged specimens have been seen, a ♀ from Kansas and a ♂ from Mt. Washington, N. H., 5,000 ft. Specimens with vestigial wings have been seen from the following localities: Nfld. (♀ Port au Basques, ♀ Mts. E. of Codroy, ♂ Little R.), N. S. (♀ Pt. Hawksbury), Me. (♀ ♀ N. E. Harbor, ♂ Treat's Is.), Mgd. Is. (♂), N. H. (♀ Shelburne, ♀ Chocorua, ♂ ♂ ♀ ♀ Rumney, ♂ Plymouth, ♀ Tamworth, ♂ Exeter), Mass. (♀ Barnstable, ♀ Boston, ♂ ♀ ♀ Cambridge, ♂ Springfield, ♂ ♂ ♀ Lowell, ♀ Norfolk Co., ♂ Wellesley, ♀ Billerica, ♂ Dedham, ♂ W. Roxbury, 3 ♂ ♀ "Mass"), Conn. (♀ Pomfret), N. Y. (♀ Sullevan

Co.), L. Superior (♀ Pt. Arthur), Ill. (♀ Ogle Co., ♂ W. Northfield), Kan. (♂ ♀ ♀ Ft. Hays, ♂ Ks.), Minn. (♂ Grand Forks), Alta. (♂ 3 ♀ Medicine Hat, ♂ 4 ♀ Calgary), B. C. (♂ ♀ Mountains between Hope & Okanagan), Wash. (♀ Spokane Falls), Mont. (♂ ♀ Bozeman, ♂ Maiden, ♂ Manard), Wyo. (♀ Cheyenne), Col. (♂ ♂ Buena Vista), No locality (♂ 4 ♀). Total specimens examined 71, of which 69, or about 97 percent, have vestigial wings.

The shape and size of the vestigial wing is remarkably constant in specimens from such widely scattered localities as Massachusetts, Kansas, and British Columbia. The wing vestige is rather thick, opaque, and wrinkled, with the costal margin thickened and the radius and cubitus visible. Other veins are not recognizable.

2. **Bembidion muscicola** Hayw.

(Plate I, Figs. 11a, b)

The wings are strictly dimorphic, fully developed or vestigial. Fully winged specimens examined from Mass. (♀ Arlington, ♂ Cambridge, ♂ Brookline); vestigially winged, from Mass. (♂ 3 ♀ Arlington, 6♂ 2 sex not det. Cambridge, ♂ ♀ Lexington, ♀ Sherborn, 1 sex not det. "Mass"), Canada (1 sex not det.), "Cal" (♂, locality undoubtedly erroneous). Total examined 21, of which 18, or about 86 percent, have vestigial wings. The latter are thin and transparent, with the costal margin thickened at least basally, otherwise without distinguishable venation.

I have carefully separated this species from *semicinctum* Notman, which I think is distinct. The 20 specimens of *semicinctum* which I have examined all have the inner wings vestigial.

3. **Patrobus longicornis** Say

(Plate I, Figs. 12a, b)

Wings strictly dimorphic, fully developed or vestigial. Fully winged specimens examined from Mass. (♀ Arlington, ♀ Brookline, ♀ Dracut), N. Y. (♂ Chateaugay L.), S. C. (♂ Camden), Ill. (♀ Pekin), Ky. (♂ ♂), Ia. (♂ Iowa City), Mich. (♂ Marquette), Wash. (♀ Pasco), No locality (♂). Vestigially winged specimens examined from Nfld. (3♂ ♀ Little R., ♂ ♂ Bay of Islands), Que. (♀ Cap Chat R. Gaspé, ♀ L. Memphremagog, ♀ Patton Spgs.), N. S. (♂ ♂ Cape Breton), N. B. (♂ southern—), Me. (♀ Cape Rozier, ♀ Isle-au-Haut), Vt. (♂ Newport, ♂ Burlington), N. H. (♂ ♀ ♀ Plymouth, 3 ♀ Rumney, ♂ Mt. Washington, 3 ♀ Pinkham Notch, ♂ Echo L., ♂ L. Winnepesauke), Mass. (♂ ♀ ♀ Arlington, ♂ ♂ Lexington, ♀ Concord, ♂ ♀ Billerica, 3♂ ♀ ♀ Springfield, ♂ ♀ Cambridge, ♀ Barnstable, ♂ Northfield, ♀ ♀ Dracut, ♀ Tyngsboro, ♀ Sharon, ♂ ♀ Wellesley, 5♂ ♀ ♀ "Mass"), N. Y. (♂ Sodus, ♀ ♀ "N. Y."), Penn. (♂ ♀ Greentown, ♂ ♂ ♀ "Penn"), Md. (♂ ♀ Laurel, ♀ "Md"), D. C. (♂ ♀ ♀ Washington), Va. (♂ ♂ ♀ Fall's Church), N. C. (♂ ♀ Linville, ♂ Andrews, ♀ Nantahala Gorge), S. C. (♀ Camden), Ky. (♀ Pineville, ♂ ♂ "Ky"), Ill. (♀ ♀ Pekin, ♀ Alton), Ia. (♀), Wis (♀ Bayfield), Kan. (♀), Alta. (♀ Edmonton, ♀ Medicine Hat), Mont. (5♂ ♀ ♀ Kalispel), Ut. (4♂ 3 ♀ Provo), Wash. (3 ♀ Pasco, ♀ "W. T."), B. C. (♂ ♂ Oliver,

♂ ♀ Osoyoos), No locality (3♂ 3♀). Total examined 131, of which 119, or about 91 percent, have vestigial wings.

There is little variation among the vestigial wings of different individuals. The length may vary either way as much as 10 percent from the example figured, and the wing is sometimes proportionately a little narrower. The membrane is usually more or less wrinkled and opaque. The costal margin is thickened toward the base, and the radius and traces of the cubitus are visible in some specimens.

4. **Micromaseus patruelis** (Dej.)

(Plate II, Figs. 1a-d)

The wings are dimorphic but the vestigial class shows more variation than in any of the preceding species. The three figures of vestigial wings show about the limits of their variation. Fully winged specimens have been examined from Que. (♂ L. Memphremagog), N. H. (♀ Starr L.), Mass. (♀ Springfield). Vestigially winged specimens from Nfld. (♂ ♀ ♀ Little R.), N. S. (♂ ♀ Medway), Gulf of St. Lawrence (♂ ♂ Coffin Is.), Me. (♀ Isle-au-Haut), Vt. (♀ So. Hero), N. H. (♂ 3♀ Pinkham Notch, ♂ ♂ ♀ Mt. Lafayette 4000 ft., ♂ ♀ ♀ Thornton, ♂ 3♀ Rumney), Mass. (5♂ 9♀ Cambridge, 3♂ Arlington, ♂ ♀ Springfield, ♀ ♀ Brookline, 4♂ 3♀ Norfolk Co., ♀ Cohasset, ♀ Nantucket, ♀ Marion, 4♂ ♀ Tyngsboro, ♂ Sharon, ♂ Lowell, ♂ Dorchester, ♀ Wellesley, 3♂ W. Roxbury, ♂ ♂ 4♀ "Mass"), N. Y. (♂ ♀ Chateaugay L.), N. J. (sex not det.), Penn. (♂), Ill. (♂ ♂ 3♀), Mo. (♂), Wis. (♀ Bayfield, 3♂ ♀ "Wis"), Mich. (3♂ ♀ ♀ and 1 sex not det. Kalamazoo), Kan. (♀), Man. (♀ Stonewall, ♀ ♀ Winnipeg), N. D. (♂ 3♀ Devil's L.), Neb. (♂), Mon. (♀ Assinniboine), Col. (♂). Total examined 107, of which 104, or about 97 percent, have vestigial wings.

Variation is chiefly in the degree of development of the apex of the vestigial wing, which is thin and more or less transparent. The costal margin, radius, cubitus, and sometimes traces of anal veins are present in the wing vestige.

I have considered *Micromaseus femoralis* (Kby.) as a synonym of *patruelis*, from which it differs by no constant character. All the fully winged as well as the majority of vestigially winged specimens would be referable to *patruelis* if the species were separated.

5. **Micromaseus corrusculus** (Lec.)

(Plate II, Figs. 2a-e)

Inner wings reduced, but variably so; not dimorphic. The specimens examined may be divided into 4 classes as follows:

1. (Plate II, Figs. 2d, e) Wing tip above side 5th ventral; wing folded in a little at tip: Mass. (♂ Lexington, ♀ Tyngsboro).

2. (Plate II, Fig. 2c) Wing tip also above side 5th ventral; wing folded lengthwise but not folded in at tip: Mass. (♀ Brookline, ♀ Lexington, ♀ Tyngsboro, ♀ Newton).

3. (Plate II, Fig. 2b) Wing tip above side 4th ventral; wing folded only lengthwise: Mass. (♀ ♀ W. Roxbury, ♂ ♀ Tewksbury, ♂ ♀ Newton, ♂ ♀ Brookline, ♂ Lexington, ♀ Arlington, ♀ "Mass.").

4. (Plate II, Fig. 2a) Wing tip above side 3rd ventral; wing folded only lengthwise: Mass. (7♂ 6♀ W. Roxbury, ♂♀ and 1 sex not det. Cambridge, ♂♀♀ Lexington, 4♀ Newton, 4♂ 3♀ Tewksbury, ♀ Holliston, ♂ Wayland, ♀ "Mass.").

Total examined, 50, as follows: Class 1— 2, or 4%
2— 4, or 8%
3—11, or 22%
4—33, or 66%
100%

Variation is continuous; the division into classes, entirely arbitrary. The wings are thin and transparent, reduction affecting chiefly the apex beyond the pterostigma. The venation is nearly complete.

6. **Celia remotestriata** Dej.

(Plate II, Figs. 3a-e)

Wings dimorphic, but reduced wings showing great variation. Specimens with full, complexly folded wings (Plate II, Fig. 3e) examined from Nfld. (♀ Codroy), N. H. (♂♀♀ Rumney), Mass. (♀♀ Cambridge, ♂♂ Ipswich), Man. (3♀ Magnus), Col. (♂♀ Leavenworth Vy., 3♂ Breckenridge, ♀ Georgetown, ♂ Silver Plume, ♂ "Col"), N. M. (♂♀ S. Fé. Cañon, ♀♀ "N. M."), Nev. (♂ Reno), Ut. (♂ Marysvale, ♂♀♀ "Ut"), Mon. (♀♀ Havre), B. C. (♀ Mts. between Hope and Okanagan). Specimens with reduced wings divided into the following arbitrary classes:

1. (Plate II, Fig. 3d) Wing tip above side 5th ventral: B. C. (♀ Peachland), N. M. (♀ S. Fé Canon).

2. (Plate II, Fig. 3c) Wing tip above side 4th ventral: Mass. (♂♀ Cambridge, ♀♀ Ipswich), Col. (♂ Florissant, ♀♀ Breckenridge, ♂ Como, ♀♀ South Park), N. M. (♀ Jemez Spgs.), Wyo. (♂♂♀ Cheyenne, ♀ Yellowstone Park).

3. (Plate II, Fig. 3b) Wing tip above side 3rd ventral: Col. (♂ Leadville, ♂ Breckenridge), N. M. (♀ S. Fé. Canon, ♂ "N. M."), Cal. (♂♂♀ Bodie).

4. (Plate II, Fig. 3a) Wing tip above side 2nd ventral: Wyo. (♀ Cheyenne), Cal. (♀ Bodie).

Total examined, 57, as follows:
Fully winged—31, or 54 %
Class 1— 2, or 3.5%
2—15, or 27 %
3— 7, or 12 %
4— 2, or 3.5%
100 %

The reduced wings are thin and transparent, with costal thickening, radius, cubitus, and anal system distinct.

7. **Platynus retractus** (Lec.)

(Plate II, Figs. 4a-e)

Wings chiefly dimorphic, but full and vestigial classes connected by a few intergrades. Specimens with full wings (Plate II, Fig. 4e)

examined from Que. (♀ ♀ L. Memphremagog), Me. (♂ Isle-au-Haut), N. H. (♂ ♀ Mt. Moosilauke, ♀ Exeter), Mass. (♀ Concord, ♀ Sherborn, ♀ Marion, ♀ Dover, ♀ Tewksbury, ♂ "Mass"), N. Y. (♀ Chateaugay L.).

Specimen with wings asymmetrical, right full and folded, left reduced, reaching to above 3rd ventral, from Mass. (♂ Tyngsboro).

Specimens with reduced wings divided into the following arbitrary classes:

1. (Plate II, Fig. 4d) Wing tip above side 4th ventral: Que. (♂ L. Memphremagog), N. H. (♂ Mt. Madison), Mass. (♂ Tyngsboro).

2. (Plate II, Fig. 4c) Wing tip above side 2nd ventral: Mass. (♂ Marion), N. Y. (♀ Chateaugay L.).

3. (Plate II, Figs. 4a, b) Wing tip above side 1st ventral, or not reaching 1st ventral: Que. (♂ ♀ L. Memphremagog), Me. (♀ Cold Spring Harbor, 3♀ 3♂ Isle-au-Haut), N. H. (♂ Randolph, ♀ Mt. Moosilauke, 3♂ 5♀ Mt. Washington, ♂ ♀ ♀ Mt. Madison, ♀ ♀ Mt. Lafayette, ♀ Mt. Cardigan, ♂ ♂ ♀ ♀ Rumney), Mass. (♂ ♂ Lexington, ♂ ♀ Concord, ♀ Arlington, 6♂ ♀ ♀ Dracut, 3♂ ♀ Tewksbury, 3♂ ♀ Tyngsboro, 3♂ ♀ Marion, ♀ Lowell, ♀ Brookline, ♂ "Mass"), N. Y. (♂ ♂ ♀ ♀ Chateaugay L.), Ont. (♀ Michipicoten R.).

Total examined, 81, as follows:

Fully winged—13, or	16%
Asymmetrical— 1, or	1%
Class 1— 3, or	4%
2— 2, or	2%
3—62, or	77%
	100%

The reduced wing is thin and transparent, more opaque in the most reduced forms. Venation is nearly complete except in the most reduced forms, in which costal thickening, radius, and cubitus only are distinguishable.

8. **Chlaenius aestivus** Say

(Plate II, Figs. 5a-f)

Wings extremely variable. Material examined as follows: Wings full (Plate II, Fig. 5f): Fla. (3♂ ♂ Croom, near Brooksville), No locality (♀). Specimens with reduced wings divided into the following arbitrary classes:

1. (Plate II, Fig. 5e) Wing tip above side 5th ventral: Mass. (♀ ♀ Holyoke, ♀ Springfield, ♀ Malden, ♀ Chicopee, ♂ ♀ Amherst), Conn. (♂ Suffield).

2. (Plate II, Fig. 5d) Wing tip above side 3rd ventral: D. C. (♂ Washington), Md. (♂), N. C. (♂ Elizabeth City), S. C. (♂ ♂ ♀ Camden), Ala. (♀ Mobile), La. (♂), No locality (♀ ♀).

3. (Plate II, Fig. 5c) Wing tip above side 2nd ventral: N. J. (♂ Princeton, ♀ Rivervale, ♂ ♀ "N. J."), Penn. (♂ ♂ Harrisburg, 3♂ "Pa."), Md. (♂ Baltimore, 3♂ "Md."), D. C. (♂ ♀ Washington), Va. (♀ Wingina), S. C. (♂ ♂ ♀ Camden), Ala. (♀ Mobile), La. (♀), Ill. (♂ ♂ Richland & Lawrence Co.), No locality (8♂ 4♀).

4. (Plate II, Figs. 5a, b) Wing tip over side 1st ventral: N. J. (♀ Princeton), D. C. (♀ Washington), S. C. (♀ Camden), Geo. (♂), Ala. (♂ Mobile), Miss. (♂♂♀), Ill. (♀♀ Richland & Lawrence Co.), No locality (♂).

Total examined, 68, as follows:

Fully winged— 4, or	6%
Class 1— 8, or	12%
2—10, or	15%
3—35, or	51%
4—11, or	16%
	100%

Membrane transparent in larger; thicker and opaque in smaller reduced wings. Longitudinal veins exceptionally strong in all. Venation nearly complete in Class 1; progressively reduced till only a costal thickening, radius, and cubitus are distinct in the smallest wing vestiges.

The geographical distribution of wing classes is remarkable. The fully winged specimens, so far as labeled, are all from Florida; those of Class 1, which make the nearest approach of any of the others to a fully winged condition, are all from Massachusetts and Connecticut; the other classes, with least developed wings, are from intermediate regions.

9. **Cymindis cribricollis** Dej.

(Plate III, Figs. 1a, b)

Wings strictly dimorphic, fully developed or vestigial. Fully winged specimens examined from N. H. (♀ Mt. Washington), Mass. (♂♂ Norfolk Co., ♂ Brookline, ♀ Tyngsboro, ♀ Lexington, ♀ "Mass"), Mich. (♀ Northwood), Ont. (♂ North Bay). Vestigially winged from Nfld. (♂♂♀ Little R., Codroy), Me. (♀ Portland, ♂ Rangely L., ♂♀ Damaris Cove, ♂ Mt. Desert, ♂♂♀♀ Isle-au-Haut, ♀ Cape Rozier), Vt. (♂), N. H. (♀ Franconia, ♂♂ 3♀ Rumney, ♂ Tamworth, ♂ Mt. Cardigan, ♀ "N. H."), Mass. (♀ Lowell, ♀ Wayland), N. Y. (♀ Indian L.), Ont. (♀ North Bay), Wis. (♂ Bayfield). Total examined 37, of which 28, or 76 percent, have vestigial wings.

There is hardly any variation in the vestigial wing, the apex of which lies above the side of the first ventral segment, or just above its posterior margin at the side, in all of the 28 specimens examined. Costal thickening, radius, cubitus, and traces of one anal vein are visible in the vestigial wimg. The membrane is rather thin and transparent.

I have not included specimens from the West in tabulating this species because I have not succeeded in classifying the western representatives of the species satisfactorily.

10. **Cymindis pilosa** Say

(Plate III, Figs. 2a-c)

Wings strictly dimorphic, fully developed or vestigial. Fully winged specimens examined from N. H. (♂ Franconia, 3♂ ♀ Rumney), Vt. (♀ northern—), Mass. (♀ Tyngsboro, ♂ Boston, ♂ Dorchester, ♀ Mt. Tom, ♂ Arlington, ♀ Nantasket, ♀ "Mass."), N. Y. (♀ Long Is.), Penn. (♀), Va. (♀), Mich. (♂ Bloomfield), Neb. (♀), Tex.

(♀), No locality (4♂ ♀ ♀). Vestigially winged from N. H. (3♂ Shelburne, 4♂ 5♀ Rumney, ♀ Orford), Vt. (♂), Mass. (♂♂ ♀ Marion, ♂ Duxbury, ♀ Mt. Tom, ♂♂ ♀ ♀ and 1 sex not det. Norfolk Co., ♂ Milton, ♀ Concord, ♂ Brookline, ♂ Groton, 6♂ 6♀ "Mass."), Conn. (♀ Saybrook), Md. (♂♂), Va. (♀ Ash Grove, ♀ "Va."), Mich. (♀ Galesburg, ♂ Bloomfield), No locality (♂♂ 6♀). Total examined 80, of which 55, or 68 percent, have vestigial wings.

There is practically no variation in the length of the vestigial wing. Its apex is above the side of the first ventral in all of the 55 specimens examined. There is a little variation in the form of the apex, however, as shown in the figures. The membrane is more or less transparent, with costal thickening, radius, cubitus, and traces of an anal distinguishable.

11. **Cymindis borealis** Lec.

(Plate III, Figs. 3a, b)

Wings strictly dimorphic, fully developed or vestigial. Fully winged specimens examined from Wis. (♂♂ Bayfield), Alta. (♀ Edmonton), B. C. (♀ ♀ Mts. between Hope and Okanagan). Vestigially winged from Me. (♂♂ 3♀ Damaris Cove Is.), N. H. (♂ Shelburne), Vt. (♀ northern—), Mich. (♂), Wis. (♀ Bayfield, ♂ "Wisc"), B. C. (♀ ♀ Mts. between Hope and Okanagan), No locality (♂). Total examined 18, of which 13, or 72 percent, have vestigial wings.

The vestigial wing is very constant; the apex invariably reaches to above the side of the first ventral segment. The wing vestige is thin, more or less transparent.

12. **Cymindis neglecta** Hald.

(Plate III, Figs. 4 a, b)

Wings strictly dimorphic, fully developed or vestigial. The only fully winged specimen seen is from "N. H." (♂). Vestigially winged examined from N. H. (3♂ Lyndeboro), Mass. (♂♂ 3♀ Tyngsboro, ♀ Springfield, ♂♂ ♀ Marion, ♂ Brookline, ♀ ♀ Dracut, 3♂ Lowell, ♀ Lexington, ♀ Billerica, ♀ "Mass."), Conn. (♀ ♀ Pomfret), Penn. (♂), Va. (♂ Lee Co.), Mich. (♂ Northwood, ♀ Galesburg), No locality (♀). Total examined 29, of which 28, or 97 percent, have vestigial wings.

Vestigial wings are very constant, with apices above, or just reaching, the side of the first ventral segment. The membrane is nearly transparent, with costal thickening, radius, and cubitus present.

13. **Cymindis elegans** Lec.

(Plate III, Figs 5a, b)

Wings strictly dimorphic, fully developed or vestigial. Only one fully winged specimen seen, a ♀ without locality. Vestigially winged from Mass. (♂♀ Springfield, ♂ Lowell, ♀ Tewksbury, ♂ Billerica, ♀ "Mass."), N. C. (4♂ ♀ ♀ Macon Co., ♀ Southern Pines, ♂ "N. C."), S. C. (♀ ♀), No locality (♂ ♀). Total examined 19, of which 18, or 95 percent, have vestigial wings.

Vestigial wings only slightly variable, falling short of or just reaching to first ventral at side, and therefore slightly smaller than in the other Cymindis. Membrane less transparent than in the preceding species; costal thickening and radius distinct, cubitus nearly absent, traces of anals present.

14. **Cymindis americana** Dej.

(Plate III, Figs. 6a, b)

Wings strictly dimorphic, fully developed or vestigial. Fully winged specimens examined from N. H. (3♂ Rumney), Mass. (♂ Tewksbury), N. J. (♂♂). Vestigially winged from N. H. (♀ Rumney), Vt. (♂♀), Mass. (3♂ ♀♀ Tyngsboro, 3♂ ♀ Tewksbury, ♀ Mt. Tom, ♂ Lowell, ♂ Dracut, ♀♀ Billerica, ♀ Arlington, ♂ Springfield, ♀♀ "Mass."), Conn. (♀), N. J. (♀♀ Princeton), Penn. (♀♀), Ill. (♂), Va. (♂ Straight Cr.), Mich. (♀ Detroit, ♀ Northwood), No locality (5♂ 3♀). Total examined 44, of which 38, or 86 percent, have vestigial wings.

Vestigial wings show little variation, invariably reaching to above or just beyond the first ventral segment at side. Membrane nearly transparent, with costal thickening, radius, cubitus, and traces of anals visible.

In addition to these eastern North American Carabidae, I have collected two western American species with dimorphic wings. One is *Bembidion convexulum* Hayw., a relative of *B. muscicola*. I have both short and long winged specimens from North Bend, Washington, July 31, 1927. The other is a species of Patrobus, possibly *fossifrons* Esch. Both long and short winged specimens are from Victoria, Vancouver Island, Aug. 11, 1927. Very recently I have discovered wing dimorphism also in *Tachyura granaria* (Dej.) of the eastern United States, in *Limnastis americanus* Darl. of Cuba (p. 152), and in *Bembidion subapterum* Darl. from Colombia (p. 153).

I have noted references to the following additional dimorphically winged Carabidae from different parts of the world: *Carabus granulatus* L., *C. clathratus* L., *C. maurus* Adams, and *C. maeander* Fisch., the first three of Europe, the last of northern Asia and America, have the wings usually vestigial but sometimes large and functional, according to Lapouge (1929, 117). The wing dimorphism of the first two species is described by Schulze (1912) and Oertel (1924). Oertel found in *C. granulatus* intermediate stages between the full and vestigial wings, so this species is really polymorphic rather than dimorphic. *Carabus morbillosus alternans* Pallrd., according to Krausse (1913), also has two forms of inner wings, but both forms are vestigial. The European *Bembidion ustulatum* L. is dimorphically winged (Jackson 1928, 717) and so apparently is *B. molokaiense* Shp. of the Hawaiian Islands (Sharp 1903, 181–2; Perkins 1913, LI.). Jeannel (1926, 331–7) states that, among the Trechini, *Trechus obtusus* Er., *T. quadristriatus* Shrank, *T. fulvus* Dej., and *T. tyrrhenicus* Jeann., all of European-north-African regions, are dimorphic (or, in *obtusus*, possibly polymorphic), but that the long and short winged forms occur in different localities. *T. subnotatus* Dej., *T. austriacus* Dej. and *T. rufulus* Dej., of the same

general geographical region, are sometimes dimorphic in single localities, and *Trechisibus femoralis* Germ. (*politus* Brullé) of Chile and *Plocamotrechus parilis* Pér. of South Africa are also di- or polymorphic. Among the Pterostichini, *Pterostichus* (*Omaseus*) *minor* Gyll. and *Pt.* (*Omaseus*) *vulgaris* L. both have dimorphic wings, according to Sharp (1913) and Maran (1927, 135) respectively. The latter author finds slight *sexual* dimorphism in the genus Abax, in which, he states, the vestigial wings are longer and narrower in the ♂ than in the ♀. Maran (*l. cit.*) mentions wing dimorphism also in *Calathus melanocephalus* L., of the Platynini. Finally, *Dioryche interpunctata* (Dej.), of the tribe Harpalini, from the Seychelles, is dimorphic, one class of individuals having the wings considerably longer than the elytra, the other having them equal to the elytra (Scott 1912, 249). This list is certainly far from complete. There must be many other species of Carabidae even in Europe and North America, to say nothing of less well known parts of the world, in which the wings will eventually be discovered to be di- or polymorphic.

Asexual dimorphism of the flying wings is by no means confined to Carabidae among beetles, but is known to occur in numerous families including (*Cf.* chiefly Jackson, 1928) Cicindelidae, Corylophidae, Ptiliidae, Hydrophilidae, Dryopidae, Dermestidae, Chrysomelidae, and Curculionidae, while striking sexual wing dimorphism (♂ with functional wings, ♀ not) occurs in some Lampyridae, Meloidae, Lucanidae, Scarabaeidae, Elateridae, Dascyllidae, Cerambycidae, and others. Probably dimorphic species are to be expected in nearly every family of beetles, but in most of them the condition of the wings is not yet very well known. It is interesting to recall that dimorphically winged beetles, of unspecified kinds, were known even to Darwin, who mentions them briefly in his discussion of rudimentary organs in the "Origin of Species." Of course asexual dimorphism of the wings occurs in many orders of insects beside the Coleoptera—in some Orthoptera (Chopard and Bellecroix 1928), Dermaptera (Pantel 1917), and Hemiptera to mention only a few, and sexual wing dimorphism is even more widely spread.

When the vestigial wings of different Carabidae are arranged in an arbitrary series, beginning with the least reduced and grading to the smallest vestiges, it is obvious that the first step morphologically (but not necessarily phylogenetically, if reduction is by mutation) involves the loss merely of the terminal part of the wing, beyond the pterostigma. The rest of the wing may be comparatively little changed, except that it is somewhat narrowed. This agrees with Jeannel (1926, 331–2) and is shown especially in my figures of *Micromaseus corrusculus*, *Celia remotestriata*, *Platynus retractus*, and *Chlaenius aestivus*. Further reduction involves a more or less equal diminution of all parts of the wing, from the now subapical pterostigma to the base. In still greater reduction, however, the extreme basal part is apparently more persistent than the rest of the wing, which often becomes no more than a thin, narrow, strap-shaped appendage of the basal part (see especially figures of Carabus, *Bembidion muscicola*, and Cymindis). This apical appendage is sometimes inconstant within a species (*Cf. Carabus vinctus*, Pl. I,

Figs. 10a, b), and shows much greater variation in series of related species (*Cf.* the species of Carabus, Pl. I, Figs. 6–10) than the base of the wing vestige does. In the most advanced stages of atrophy the variable apical portion disappears entirely, and there is left a wing vestige which is apparently the homologue of only the extreme basal portion of the normal wing.

It has been suggested by several writers that wing atrophy may be a sort of neoteinia, the wing vestige perhaps corresponding to the pupal wing, but the fact that the vestige is not homologous with the entire wing but represents merely its basal portion argues against this. Moreover, as Jackson (1928, 728) points out, the dissimilarity in the shape of the wing vestiges among various brachypterous beetles would be hard to explain by a theory of arrested development, for vestigial wings of about the same size are sometimes of entirely different shapes in closely related species.

In arbitrary series of progressively smaller wing vestiges, the venation (Pl. I, Fig. 11b) is progressively reduced also. The weakly developed media, the cross veins, and the apical portion of the first anal tend to disappear first; later the entire anal system is lost. In the commonest type of vestigial wing there are present only the costa along the anterior margin at base, the radius (with which the subcosta may perhaps be fused) which parallels the costal margin in the basal part of the wing but often becomes marginal near the apex, and the cubitus which branches from the radius and runs diagonally across the wing. The radius and cubitus, which are strong convex veins in the normal wing, are especially strong in the wing vestige, but in the last stages of wing degeneration, in the Cychrini or Amblycheila, for instance, even they are absent, leaving the wing vestige simple and sacklike.

The foldings of the wing membrane, too, disappear in graded series of wing vestiges. The folding in of the tip is usually lost in even slight cases of atrophy, although there are traces of it in the largest form of the reduced wing of *Micromaseus corrusculus* (Pl. II, Fig. 2e). Longitudinal folds are often present in wings only half the length of an elytron, as shown in *Celia remotestriata* and *Platynus retractus* (Pl. II, Figs. 3c, 4d). The folding under of the basal edge of the anal area is still more persistent, and in fact remains as long as the vestige retains its wing-like form. This is because the folding is necessary to allow the posterior, basal corner of the wing to articulate with the posterior notal wing process.

A series of secondary morphological changes has accompanied or followed the atrophy of the inner wings during the phylogeny of many Carabidae. The metathorax, which is normally capaceous and strong, to contain the flying muscles and allow for their attachment, often becomes much shortened and weakened after the muscles degenerate. The metanotum especially is affected, the heavily chitinized sclerites coming to form only a narrow, transverse yoke behind the scutellum, as in Scaphinotus (Pl. I, Fig. 5). The metepisterna, too, are much shortened in species with vestigial wings. As the metathorax becomes contracted, the elytral humeri, which are fitted or "coapted" (Corset 1931) with it, become correspondingly narrowed and rounded and in

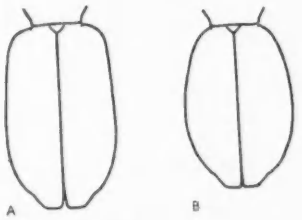
some cases obliterated, as they are in the Cicindelid Tricondyla. There is an obvious physical connection between atrophy of the wings, atrophy of wing muscles, degeneration of the metathorax, and finally rounding of the humeri. The elytra tend also, after wing atrophy, to become ankylosed, or to be locked rigidly together along the suture by the evolution of a very efficient tongue and groove joint (Corset, *l. cit.*). The joint is present in simple form in fully winged Carabidae, of course, and needs only to be improved. The strengthening of the sutural joint may be an adaptation compensating for the loss of supporting structures at the scutellum or humeri during the degeneration of the metathorax, so elytral ankylosis too may have a real physical connection with wing atrophy. Sometimes, especially among desert species, the elytra are thickened and roughened (Van Dyke 1933). Sometimes, especially among cavernicolous or subterranean species, the eyes are lost and depigmentation occurs. That loss of eyes is directly correlated with wing atrophy, the eyes disappearing as a rule only in

TEXT FIG. 1. *Limnastis americanus* Darl. Lateral view (semi-diagramatic, from camera lucida outlines, greatly enlarged) of left side of head of (A) specimen with inner wings fully developed, (B) specimen with inner wings vestigial, about one-third as long as elytron. e=eye; m=edge of mouth cavity. Both specimens ♂♂ from Soledad, near Cienfuegos, Cuba, June, 1929.

flightless species, has been pointed out by Jeannel (1926) for the Trechini and by Scott (1933, 342) for some other Coleoptera, and is true, too, of our blind American Carabidae. It is, of course, obvious that vision is necessary to controled flight. In some insects, however, there seems to be a direct physiological or genetic connection between wing atrophy and loss of eyes, for the two processes are sometimes correlated in individuals of polymorphic Orthoptera and Hymenoptera (Chopard 1932, 492, and papers there cited) and possibly in some Pselaphid beetles. Among Carabidae, the eyes are directly affected by wing atrophy only rarely. The only case I know is in the minute, dimorphically winged Cuban *Limnastis americanus* Darl. (Text Fig. 1). Of 17 specimens which I have been able to examine carefully, 14 (3♂, 11♀) have long inner wings and are probably capable of flight; 3 (all ♂) have vestigial wings. The eyes are never strongly developed. In the long winged specimens they are slightly transverse and are separated from the margin of the mouth below by about half or less their own diameter, although there is a little variation. In the short winged individuals the eyes are nearly round, obviously smaller, and separated

from the mouth by a space about equal to their diameter (the further the lower edge of the eye from the mouth, the greater the eye's reduction). The eyes are almost always weak in the genus Limnastis; sometimes, indeed, they are quite absent. They seem to be in the process of atrophying, and may for that reason be unstable and liable to be influenced by slight genetic or physiological variations. It should be noted that Harnly (1930), in his detailed discussion of the various effects of the "vestigial" wing mutation of Drosophila, does not mention any effect upon the eyes. A statistical study of the size of the eyes in flying and flightless species of beetles should be very interesting—presumably flightless species would, on the average, have smaller eyes.

Sometimes other secondary modifications, especially shortening of the metepisterna and rounding of the humeri, distinguish the short from the long winged individuals of dimorphic beetles (Kolbe 1921, 402; Maran 1927, 136; Jackson 1928, 678). Such secondary differences seem to be rare among Carabidae. Oertel (1924) found none among



TEXT FIG. 2. *Bembidion subapterum* Darl. Outline (from camera lucida sketches, × about 10) of elytra and base of prothorax of (A) specimen with inner wings fully developed, (B) specimen with inner wings very minute, not reaching first abdominal segment. Both specimens ♀ ♀ from Sierra Nevada de Santa Marta, Colombia, 8,500–11,000 ft., July 21, 1928.

the dimorphic Carabus he examined, and there seems to be none among the eastern North American dimorphic species of the family. However, in a small series of the dimorphic *Bembidion subapterum* Darl. from the Santa Marta Mountains of Colombia, the brachypterous specimens have the humeri obviously more narrowed than the single macropterous individual (Text Fig. 2). Why some species should and and others should not show secondary differences correlated with dimorphic wings I do not know.

The vestigial wings of Carabidae are usually symmetrical, *i. e.* practically identical in gross structure on the left and right sides, but numerous cases of distinct asymmetry have been recorded in *Carabus auratus* by Schulze (1912, 193) and Hass (1914), in other species of Carabus by Oertel (1924, 47), and in Pterostichus by Maran (1927, 136–7). The asymmetry consists of differences in shape especially of the apical portion of the wing vestige. I am inclined to think that this asymmetry, which Hass has figured with special care (*l. cit.* 274–5), and which affects the finer details of the shape of the wing rather than its degree of development, is of no more significance than asymmetry

in the exact details of elytral punctuation or in other minor characters. I know of only one case of striking asymmetry of the wings—in a ♀ of *Platynus retractus* from Tyngsboro, Mass. The right wing is fully developed and complexly folded, but the left is much reduced, only about ⅓ as long as an elytron, not folded, with pterostigma nearly apical and venation about as in Plate II, Fig. 4d except that the media, which is folded under in the figured wing, is clearly visible. Both wings in the asymmetrical specimen are in good, clean condition and have been examined under a binocular microscope.

There is, among dimorphic Carabidae, little correlation between wing length and sex, range, or season. Both sexes are known to be dimorphic in all of the dimorphic eastern North American species except in *Cymindis neglecta, elegans,* and *americana,* and when more material is available the dimorphism of these species will almost certainly be found to be asexual too. The sexual wing dimorphism recorded by Maran (1927) in Abax is slight, not comparable with the striking asexual dimorphism of many Carabidae. With regard to distribution, *Chlaenius aestivus* (under which see p. 146) is the only American Carabid in which length of wing has been found to be at all closely correlated with locality. The long winged form of *Micromaseus patruelis* may occur only in the East, and of *Cymindis borealis* only in the West, but the number of specimens examined is not large enough to be conclusive. The proportion of short and long winged individuals is known to vary locally in some dimorphic European Carabus and probably does so in some of our dimorphic species, and Hoffman (1925) and Jeannel (1925) say that certain Carabus and Trechus are short winged in some localities, long winged in others. Nevertheless the general rule certainly is that long and short winged individuals of dimorphic species occur together; the two forms are not dependent on geographical isolation. Finally, since practically all of our Carabidae, at least in the northern states, have only one generation a year, any possibility that their wing dimorphism is seasonal is at once eliminated. In any case long and short winged individuals of a species are frequently found at the same place and time. It is to be hoped that coleopterists will collect and analize more comprehensive data on single dimorphic species as they have opportunity. There is a chance for very interesting work by amateur collectors here.

Only a little is known of the use of wings by dimorphic Carabidae. Lapouge (1929, 117), Hoffman (1925) and others state that the long winged individuals of several dimorphic European Carabus fly. In preparing my list of New Hampshire Carabidae I found only one specimen each of *Carabus serratus* and *Micromaseus patruelis* from the high, open summits of the Presidential Range, and in each case the specimen turned out to be strongly winged, an exceptional condition in each species. These two individuals must certainly have flown and flown well to reach the summit of the Range even with a favorable updraft of wind. Probably the long winged individuals of many other dimorphic Carabidae fly too. At least there is no evidence that dimorphism is correlated with disuse of wings.

Dimorphism and polymorphism of wings seem at first glance to be different phenomena, but examination of series of species shows that all

sorts of intermediate conditions occur. For example if we start with the sharply dimorphic species such as *Carabus serratus*, *Bembidion muscicola*, and the six dimorphic Cymindis, the first step toward polymorphism is exemplified by *Patrobus longicornis* and *Micromaseus patruelis*, in which the wings are dimorphic but the vestigial class somewhat variable. Next, in *Platynus retractus*, there is a stage in which most individuals have either full or minutely vestigial wings, but the vestigial class is variable and, further, the full and vestigial classes are connected by a few intermediates. This species might be called either dimorphic with occasional intermediates, or polymorphic with two definite modes of variation near which the great majority of individuals fall. *Celia remotestriata*, also polymorphic, also has two modes of variation, for individuals most commonly have the wings either full or reaching only to the 4th or 5th ventral abdominal segments, but the modes are closer together than in *Platynus retractus* and the approach to strict dimorphism is less close. Finally in *Chlaenius aestivus* and *Micromaseus corrusculus*, which are polymorphic, variation is more or less continuous about a single mode. Of course this series is not phylogenetic. There is no reason to think that a single species goes through all these stages in losing its wings. Nevertheless I think that these examples do show that wing polymorphism or continuous variation and wing dimorphism are closely related phenomena among Carabidae. They are perhaps phases of a single phenomenon.

How do di- and polymorphism of wings originate? I think it is unquestionably through mutation. This is most obviously true in the strictly dimorphic species in which the vestigial wings show little variation, and where in each species they are probably the result of a single sort of mutation, which may, however, be recurrent. Wing polymorphism is presumably due to the occurrence of several sorts of mutations affecting the wings of the same species. It is well known experimentally that mutations to a short winged condition do occur in some insects, for example in the laboratory Drosophila and in Habrobracon (Whiting 1926). Breitenbecher (1925) records an apterous mutation in a beetle, *Bruchus quadrimaculatus* (Fab.), too. Jackson (1928) has found that the long and short wings of a dimorphic weevil, *Sitona hispidula*, are inherited in Mendelian fashion, and in this case the dimorphic wings seem certainly to be the result of mutation. And, so far as I can see, mutation supplies the only reasonably satisfactory explanation of the simple, asexual wing dimorphism described in the preceding pages. Even before the study of genetics had reached the proportions it has now, Brues (1908) suggested that mutation was probably a factor in the production of vestigial wings among insects, and the evidence points far more strongly in that direction today than it did then, and has led numerous other authors to connect mutation with wing dimorphism and atrophy. The rôle of mutation in wing atrophy will be discussed in more detail in Part III; for the time being it may be concluded merely that atrophy frequently does occur through mutation.

It is hardly necessary to say that, in view of the extraordinary variation which occurs not only among closely related species but within single species, the state of the wings must be used as a taxonomic

character only with the greatest care, after examination of long series. It is interesting to see how different a point of view the present day coleopterist must adopt from that of Sharp, who, in Fauna Hawaiiensis (1903, 179) says, "I have invariably treated a species in which the wings are capable of being used for flight as of a different genus from one in which they are useless for this purpose."

So much for the morphological side of wing atrophy. More detailed descriptions of the microscopic structure of the wing vestiges of certain Carabidae are to be found in Oertel (1924), Maran (1927), and other papers. The following pages will be concerned not with structure but chiefly with the relation of flying and flightless Carabidae to their environment, and with various factors which seem to have caused or influenced wing atrophy.

Part II. Ecology

Many functionally winged Carabidae fly well, and it will be interesting to see, so far as is possible, under what conditions they fly and whether and how flight is useful to them.

In the first place, flight probably helps to bring the sexes together for mating. Supposed marriage flights of Coleoptera have been described by Donisthorpe (1934), and it is common to find certain sorts of beetles, including some Carabidae, flying in numbers on favorable days, although detailed observations of their occurrence and behavior are practically nonexistant. It seems probable, however, since so many species of Carabidae manage to exist and reproduce without flying, that marriage flights play a relatively unimportant rôle in the life history of most of them. The very existence of so many flightless species is evidence, too, that the mixing of populations through flight is not indispensible to a species' vigor.

Second, flight may be useful during the ordinary daily activity of Carabidae, in procuring food, for instance. They do not hunt their prey on the wing, but some of them evidently find their way from one feeding ground to another by more or less random flights. Nevertheless the fact that many flightless Carabidae live and get food successfully in competition with winged forms shows that flight cannot be essential to them in their ordinary activities any more than in reproduction. A partial exception might be made of the species of Lebiini, which are almost unique among our eastern North American Carabidae in that many of them live in vegetation rather than on the ground. It is easy to see why wings might be more useful to these, which climb about in grass and bushes and trees, than to ground living species, and it is probably significant that practically none[4] of them has lost its flying wings, except a very few species, of Cymindis[4] and Eucaerus,[4] which have adopted strictly ground-dwelling habits. The

[4]The only possible exception to this statement is the flightless *Dromius atriceps* Lec., of the habits of which I know nothing. The species of Cymindis, of course, occur on the ground in dry fields or woods. *Eucaerus varicornis* Lec. I have taken by treading damp moss and leaves on the ground in woods near Mobile, Ala., in just the sort of habitat which the remarkably similar Staphylinoid *Brathinus varicornis* Lec. frequents in New England.

few local species of Carabini which are at least partly arboreal, especially *Calosoma sycophanta* L., *C. scrutator* Fab., and *C. frigidum* Kby. (see Burgess and Collins, 1917), also are all strongly winged, although the majority of the ground-living Carabini are not. On the other hand, I have read, although I cannot now rediscover the reference, that a few flightless Carabini of the Mediterranean region are arboreal, and Perkins (1913, LI) says that many flightless Carabidae of the Hawaiian Islands live in trees. Moreover many beetles which depend directly on plants for food have lost the power of flight, for instance the American Cerambycidae of the tribes Michthysomini, Moneilemini, and Dorcadiini, as well as a number of exotic genera, are flightless, although many of them have become ground-living as well; many European Chrysomelidae are flightless or have dimorphic wings (Rüschkamp 1927–8, Jackson 1928, 721–2, and authors cited by the latter); and many weevils, some ground-living but others arboreal, are flightless. In spite of these exceptions arboreal or semi-arboreal beetles undoubtedly are less likely than purely terrestrial ones to become flightless, and, when they do lose the power of flight, they apparently often become secondarily terrestrial. Obviously no hard and fast rule can be laid down, except perhaps in the special case recognized by Perkins (*l. cit.*) who says, "It is interesting to note that in the case of beetles, which require for their food that a tree should be in a special state of disease or decay, lasting only for a short period, e. g. the bark eating Longicorn beetles, and the burrowing Scolytidae, no case of loss of flight [in Hawaiian species] is known to occur."

Third, flight is sometimes of use to Carabidae in escaping sudden danger, although most of them rarely fly when alarmed or pursued. Even the species with functional wings usually run or hide rather than fly, so that wings give them no advantage over flightless species. There are, however, two important classes of exceptions. One includes the Lebiini, mentioned above, many of which fly actively to escape danger, and which, as has already been pointed out, probably depend more on their flying wings than ordinary ground-living Carabidae do. The other includes species which are closely associated with water. All such species are conveniently called *hydrophiles*. The contrasting term *xerophile* is applied to species living in the desert or other dry habitats, and the species of intermediate ground, neither very dry nor very wet, are called *mesophiles*. Not only do Carabid hydrophiles (many Bembidion, etc.) often fly readily when alarmed, especially when water is thrown over them, but their dependence upon wings is shown by the fact that *almost without exception species which live closely associated with water have strongly developed flying wings*. This is especially true of the inhabitants of the margins of brooks and streams. Only the experienced beetle collector will realize how completely true streamside species are lacking in the list of flightless Carabidae (List 2). A few flightless or dimorphic species (of Bembidion, Patrobus, and Micromaseus; *Platynus retractus*, *Eucaerus varicornis*, the two flightless Chlaenius, and *Acupalpus hydropicus*) are found under vegetation or other cover on the banks of brooks or ponds as well as in other places, but none of them is strictly riparian. They might be called facultative

hydrophiles, and even in this facultative group flightless species are rare.

Not only is it true that there are probably no flightless Carabidae among our strictly riparian species, and very few among our other hydrophiles, but there are several noteworthy cases, among genera which are characteristically hydrophilous, in which single species or small groups of species have adopted a drier habitat and have undergone a corresponding atrophy of flying wings. In our eastern American Bembidion, many of which are riparian and fly actively,[5] I have found wing atrophy in only three species, *B. picipes* Kby. (subg. Peryphus) and *B. semicinctum* Notm. and *muscicola* Hayw. (subg. Notaphus). These three are all found in moss or among damp leaves in shady places, not definitely associated with bodies of water, although they are facultative hydrophiles. Of course there are other winged Bembidion which are not strict hydrophiles, so that wing atrophy is not completely correlated with habitat, but it is significant that, when wing atrophy has occurred, it has invariably been among the species which are less strictly associated with water. In the genus Trechus Mr. Carl Lindroth writes[6] that the strongly winged *T. rubens* Fab. of Europe, and probably also of Nova Scotia, is chiefly riparian, while I know from experience that all our other eastern American Trechus, all of which have vestigial wings, are all mesophiles. *T. chalybeus* Dej. is found most commonly in rotten logs on our wooded, northern mountain slopes; *T. carolinae* Schffr., *hydropicus* Horn, and their allies, among dead leaves and moss on the wooded slopes of the southern Appalachian ranges, not, as a rule, near streams.

The state of affairs in Platynus is even more striking. Out of about 48 eastern North American species of the genus, most of which are hydrophiles, only five have become completely flightless. They are *P. hypolithos* (Say), *angustatus* Dej., and *gracilentus* Beut. (Platynus *s. s.*), *P. trifoveolatus* Beut. (subg. Anchomenus), and *P. obscurus* Hbst. (subg. Anchus). I have taken the first four in numbers under the bark of logs and dead trees in woods on the southern Appalachian mountain slopes. They usually occur quite without regard to streams or bodies of water, although *P. trifoveolatus* is sometimes to be found on stream banks. *Platynus obscurus* is found, near Boston, under stones in rich soil on the edges of cultivated fields, not characteristically near water. A sixth species of Platynus, *retractus* Lec., has dimorphic wings. It belongs to a group of the subgenus Agonum in which the species are particularly closely interallied. Its relatives are all strongly winged (I have examined a total of 87 specimens of the following closely related species: *P. sordens* Kby., *picicornis* Lec., *ruficornis* Lec., *gemellus* Lec., *picipennis* (Kby)., and *lutulentus* Lec.) and occur almost

[5] *Bembidion carinula* Chd. and some other species of the subgenus Odontium actually hunt and fly like tiny tiger beetles, starting up from the sand of river bars or lake shores when they are alarmed. Most other riparian Bembidion fly only when they are flooded out or dislodged from their hiding places.

[6] Letter of October 12, 1931, "*Trechus rubens* Fab. is a typical boreal species, mainly met with in woods, especially—as you have suspected—under moss and leaves at the margin of small rivulets and streams. The species flies often and very well, especially in the evening."

always in wet, swampy places. But, although *retractus* sometimes occurs in such places, it is much commoner under loose bark and in rotting logs, away from swamps or brooks, on the wooded slopes of the New Hampshire mountains, a situation in which I have never found any of its uniformly winged relatives. It is obvious that *Platynus retractus* is losing its wings and its hydrophilous habits together, although the condition of the wings of individuals is not directly correlated with habitat, and that it is on the road to both the structure and the habits of *P. angustatus* or *P. trifoveolatus*. It is not closely related to either, of course. In Platynus, as in Bembidion, the flying wings do not always degenerate when a species loses its association with water, but it seems invariably true that, when the wings do degenerate, they do so in species which are losing or have lost their water loving habits.

It is easy to find reasons why flying wings might be of more use to hydrophilous than to other Carabidae, for hydrophiles live in an environment which is especially liable to catastrophic change, not only from day to day, but seasonally, so that ability to move quickly and sometimes for long distances must be valuable. There can be no question that flight is useful in escaping floods, for instance. Small Bembidiini and other Carabidae can be seen to rush out and take wing when water is thrown over the gravel bars in which they live, and during real floods I have often seen small beetles of many sorts, marooned on grass blades or floating sticks, take wing and escape. Deane (1931), an Australian Coleopterist, writes appositely, "I have seen the air on a bright sunny day at Launching Place, during flood time, almost thick with several species of Carabidae, species which, under ordinary conditions, I have not seen flying in the sunshine." Similar observations are common, although they are not commonly published.

Probably water-loving Carabidae depend on their wings to take them to suitable new places when streams or ponds dry up. Probably, too, some species use their wings in short migrations from one habitat to another during their life histories. For instance, some swamp dwelling Carabidae and even some true water beetles, Dytiscidae and Hydrophilidae, hibernate in moss or under other cover in comparatively dry places, and they must find wings useful in finding their way from deep swamps to suitable hibernating quarters and back again. I have seen spring flights of Carabidae in which the insects were flying over and dropping into swamp land by the hundred, presumably coming from hibernating quarters.

There may be still other reasons why flight is useful to Carabidae in their association with water, but the chief point is already plain. Since hydrophilous species rarely lose their wings, although the latter often degenerate among meso- and xerophiles, flight must be exceptionally useful to them, and reasons have been found why this should be so. As corroborative evidence it may be added that most hydrophilous beetles of other families have functional flying wings. Sharp (1882, 243) says, "Wings are always present in the Dytiscidae [predaceous diving beetles] and are well developed and large, except in a very few species." The only exception he mentions is *Ilybiosoma bifarius* (Kby.). Flightless Hydrophilidae are said to be rare, too (Jackson

1928, 719). Although I have not made a systematic examination of all our species, I have looked at a considerable number of aquatic and semi-aquatic beetles of the families Amphizoidae, Omophronidae, Haliplidae, Dytiscidae, Gyrinidae, Hydrophilidae, Psephenidae, and Heteroceridae without finding a single eastern American species, except the just mentioned *Ilybiosoma bifarius*, in which the wings do not seem to be fit for flight. (The wings are reduced, of course, in a few Dryopidae, as mentioned below). Striking special examples of the use of wings by hydrophilous beetles are to be seen in the Staphylinid *Dianous nitidulus* Lec. (Darlington 1929a) which skims on the surface of mountain brooks, in the well known *Psephenus lecontei* (Lec.), and in *Lara avara* Lec. (Darlington 1929b) which run and fly on stones and logs surrounded by rapidly flowing water, and in species of Donacia, common Chrysomelidae, which fly from one floating pond lily leaf to another, often skimming the water surface. Among many families of Coleoptera, then, there is a striking correlation between hydrophilous habits and ability to fly. Flightless hydrophiles do occur, but they are rare.

The value of wings to hydrophilous beetles seems to be due largely to the imperfect adaptation of the insects to their environment. They live in or near water most of their lives, but they must nevertheless be protected against water, for most of them must have air to breath at least as adults, and certain stages of their life history must be passed on dry land. Probably the correlation between ability to fly and hydrophilous habits is not so close among some other insects, especially among those which are otherwise highly adapted for aquatic life. The Gerridae, for instance, which are thoroughly at home on water surfaces, are often dimorphically winged or, in the highly specialized marine forms such as Halobates, entirely flightless. Many spider hydrophiles, too, can run on a water surface, and get along well enough without wings. And of course the possession of gills, enabling arthropods of various sorts, including many insect larvae, to live under as well as on or beside water, must greatly reduce the value of wings. The question seems to resolve itself into a matter of compensation, i. e. the wings of hydrophilous insects apparently are rarely lost unless compensating adaptations occur. For example, a very interesting paper by Segal (1933) shows a close correlation in the family Dryopidae (aquatic beetles) between the condition of the wings and the development of the tarsi and tarsal claws, the latter being enlarged and strengthened as the wings are lost. In this case loss of power of flight is obviously compensated for by increased power of clinging to the surface of stones and logs in swiftly running water.

It should be mentioned that sea coast Coleoptera, even hydrophiles, probably do not depend upon wings nearly so much as fresh water species do. Walsh (1926) says that many British shore insects are characterized by inability or reluctance to fly. In North America *Thalassotrechus barbarae* (Horn) of California is an example of a flightless intertidal Carabid. In Florida *Scarites "californicus,"* which, according to Blatchley, Leng, and my own experience, is confined to the sea coast, has reduced wings, while both species of Scarites which

occur by fresh water have the wings well developed. The most remarkable correlation which I know of, however, is in Aegialia, a genus of Scarabaeidae, in which our only strictly coastal species (*A. arenaria Muls.*) is subapterous, while all our other species have well developed wings.

I do not know which group of non-hydrophilous Carabidae, mesophiles or xerophiles, includes the greater proportion of flightless species, for there are not many xerophiles in eastern North America. Wing atrophy is common among Carabidae of both groups. It may be a little more prevalent among xerophiles, especially among true desert species, but, judging from Brues (1908, 50) and from the brief summary of the subject by Jackson (1928, 724), the difference is not very great, and it certainly is not true that flightlessness is characteristic chiefly of desert species. Wheeler (1930, 39–79) reviews the chief ecological factors to which the fauna of the sands is exposed, and the factors are more complex and allow for a greater variety of protective adaptations than one in search of a simple explanation of wing atrophy in desert regions might suppose.

Most of the discussion thus far has dealt with the relation of wings to the environment during the life of the individual insect, but something must be said, too, of the relation of flight to the species, or to groups of individuals. There is, for example, a destruction between the geographical distribution of species and the power of flight, for it is obvious that the center of distribution in eastern North America of the most important groups of flightless Carabidae (the Cychrini, many genera or subgenera of Pterostichini, Dicaelus, Platynus *s. s.*, and subgenus Ophonus of Harpalus, for example) is the southern Appalachian region and adjacent country, which is geologically and biologically the oldest and least disturbed part of eastern North America (see Fernald 1931 for the time of availability to life of various parts of eastern North America). Statistically about 22.2 percent[7] of the species of Carabidae of North Carolina are flightless or have dimorphic wings, as compared with 17.2 percent[8] of the species of New Hampshire. This difference is probably due in part to a destruction of flightless species in the North during Pleistocene glaciation. However, *Carabus groenlandicus*, *Notiophilus borealis*, *Lyperophorus punctatissimus*, several species of Cryobius, *Calathus ingratus*, *Cymindis unicolor*, and *Harpalus fulvilabris* are confined in the East to our northern regions, north of the limit of Pleistocene glaciation, and other flightless species have ranges which include the northern part of the continent. As Fernald (1929 and other papers) has shown, there were many local unglaciated areas even within the usually accepted boundaries of late Pleistocene glaciation, and there seems to be no reason why many flightless species

[7]In obtaining this figure I have drawn up a tentative list of all species of Carabidae known to occur in North Carolina (where I have myself, collected and from where I have seen much material) or which, according to the summary of ranges given by Leng (1920) probably occur in the state. Of the total of 334 species, only 22.2 per cent have vestigial wings or are dimorphic.

[8]This is the percentage of flightless and dimorphic species among the 296 Carabidae actually recorded from New Hampshire. I have collected extensively in the state myself and have seen all available additional material.

of Carabidae may not have survived there. There is evidence in my unpublished studies of the New Hampshire fauna to show that they did. Moreover, the concentration of flightless species in the Southeast may be due only partly to elimination in the North. It may be due partly to the fact that the ice sheets have left a great extent and variety of aquatic and subaquatic habitat in the North (our thousands of lakes and swamps are an aftermath of glaciation, of course) and so have made conditions exceptionally favorable for hydrophilous, and hence strongly winged, species.

Probably, as a rule, flightless species of Carabidae occupy smaller ranges than flying ones. Certainly the flightless Cychrini and Pterostichini divide into many localized species and races in the Appalachian region. The smaller average range of flightless species can even be shown statistically. The reader may already have noticed, in the preceding paragraph, that the proportions of flightless Carabidae given for New Hampshire and for North Carolina (17.2 percent and 22.2 percent) are both below the 24.1 percent given (Part I.) for the entire eastern North American fauna. I think the apparent discrepancy is due to the fact that flightless species really are more local than others, and that their total therefore increases (by replacement of one set of localized species by others in new localities) more rapidly as increasingly larger areas are considered. Nevertheless some flightless species are very wide ranging. *Carabus chamissonis* is found, in America, from Alaska to the northern Atlantic coast, although it varies somewhat, and *Notiophilus borealis* has the same range and shows comparatively little variation. Perhaps, however, some of the widely ranging species which are apparently flightless are or recently have been dimorphic, so that they may have been dispersed by flying individuals.

Probably the use of wings in expanding the gross boundaries of a species' range is of little significance except during times of great geologic or climatic change. Ordinarily it can make little difference to a beetle in the Appalachian Mountains whether or not the species reaches the Rockies also. But the effect of flight in maintaining certain sorts of ranges may be more important. To see this it is necessary to examine the nature of a species' "range" more closely than merely to plot its boundaries or dot in collecting stations. The range of a species is, of course, never really continuous, but in the last analysis must be represented as an aggregation of points each representing a living individual at a given instant. Usually the single points will be grouped into small secondary aggregations representing stations where the species is established. The distribution of the stations will depend partly upon the relation of the species to its environment and partly on chance. Obviously the individuals of the species will often be moving, and obviously, in the course of time, stations will shift also as changes in the environment, chance, or other factors dictate. The range of a species will be to some extent fluid; there will be a constant shifting and reforming of the whole pattern. I shall not attempt to give examples of this from entomology, not because there are not examples of local fluctuations available, but because the matter is self-evident and indisputable. The same phenomenon of constant shifting not only

of individuals but of centers of abundance can be seen in other animals, most clearly in the recent history of man.

Not only are the ranges of species to some extent fluid, but the degree of fluidity, the rapidity with which range patterns change, varies greatly. Among insects the rate of variation depends partly on flight. There can be no question, for instance, that Carabidae which make random flights, which often carry multitudes of them to the tops of mountains or into the ocean, are in a much more plastic state geographically than flightless species are. One result of this is that flying species have wider average ranges than others, as already shown. Another may be that they were better able to retreat and advance during fluctuations of Pleistocene ice,[9] and this may account in part for their predominance in boreal America today, although it has already been shown that other factors may be involved. However, I think a third result is more important than either of these. It is that some flying species are probably able to exist in a more diffused and precarious habitat than will support flightless forms. They are probably able to survive in a series of temporary, constantly shifting stations because, even if a majority of stations are wiped out at one time by chance or environmental fluctuations, they will be repopulated from whatever stations remain. We see such repopulation occurring whenever we try to exterminate an actively flying insect pest. A more regular repopulation must take place from year to year among myrmecophilous insects, which, according to Prof. W. M. Wheeler, are almost always winged in the adult stage unless they have some other adaptation for getting from one ant nest to another. A flightless Carabid must be so adapted to some environment that it can exist continuously in one place or series of adjacent places, but a flying species can get along with less perfect adaptation, or rather power of flight compensates for the absence of other useful adaptations, if not during the lives of most single individuals, at least during the history of the species. Of course the continual shifting and eradication of stations and repopulation with winged individuals must tend to maintain wings in a species even if a tendency toward wing atrophy is otherwise present, and this may in

[9] When I first began to read books on zoögeography and found writers speaking of the "retreat" of organisms before Plesitocene ice, I visualized a continuous southward migration of individuals and wondered how the ones hundreds of miles south of the glaciers knew which way to go. There seemed to be no reason why they should instinctively have gone south merely because their local habitat started to change. Probably it is nearer the truth to think of a "retreating" species as one with a fluid range in which random movements of individuals occur in all directions (much like the movements of molecules in a gas), so that all suitable areas are likely to be occupied. During the advance of an ice sheet the country more and more to the south would be populated by boreal species not because of special migrations but as a result of the ordinary behavior of the species, which would automatically occupy suitable ground to the south or in any other direction where such ground occurred, and would simply be wiped out in the north if the climate changed sufficiently. Thus a range might be shifted southward without any tendency for individuals to coördinate their movements in that direction. Perhaps I shall be criticized for discussing so obvious a matter as this in detail. I have done so more to illustrate my text than to criticize zoögeographers, most of whom presumably understand the matter already.

part explain why so many species retain the power of flight even though most individuals seem to depend very little on their wings.

Before trying to answer the questions of why and how flying wings atrophy, it will be well to review some of the pertinent conclusions which have been reached thus far. First (Part I.) it has been found that about a quarter of the species of Carabidae of eastern North America have the inner wings atrophied, although sometimes, in dimorphic species, only in a proportion of individuals, and it has been found that wing atrophy has occurred in a surprising number of different phylogenetic groups. At least in the dimorphic species, and probably in the others, atrophy has apparently originated by mutation. In looking for correlation between wing use and wing atrophy (Part II.) it has been found that, taking the Carabidae as a whole, they have not been observed to depend much on their wings. There seems to be no reason why wing atrophy should handicap the ordinary Carabid very much, and this agrees with the first determined fact, that the wings have atrophied in a variety of species. But certain ecological groups have been found, the arboreal and especially the hydrophilous ones, in which the flying wings are rarely lost, and reasons have been found, based on field observation, why flight should be especially useful to these species. In short it has been found that *flying wings have frequently tended to atrophy among Carabidae of diverse sorts except in ecological groups where the wings are observably useful to the insects.* Flying wings probably also increase the chances of survival of certain sorts of species even though flight is of little use to most individuals of the species, but this is comparatively unimportant for the moment.

Part III. Processes of Atrophy

The atrophy of the flying wings of beetles and other insects has been discussed a number of times (the most recent comprehensive treatments by Coleopterists are by Jackson, 1928, and Rüschkamp, 1927–8) and various explanations have been suggested, but no agreement has been reached as to how or why atrophy occurs. One of the oldest and most widely held theories is that of natural selection, that, granted variation, species tend toward a flightless condition in environments where weak winged or flightless variants have a better chance than strong winged or flying ones to survive. The classic example, elaborated by Darwin (1859) from data supplied by Wollaston (1854) through his study of Madeiran beetles, is the atrophy of wings of island species, among which it is supposed that strong winged individuals often fly or are blown into the sea and die without reproducing, while weak flying or flightless ones stay and breed. Wing atrophy is often supposed to take place in a similar way among mountain beetles. However, island and mountain species, in their special environments, are special cases which do not make up the bulk of our eastern North American Carabid fauna. Selection certainly plays some part in wing atrophy even among our lowland species,[10] but it seems as likely sometimes to retard atrophy as to accelerate it. Among hydrophiles, for instance, selection probably maintains the wings by eliminating flightless variants. The forces of selection are reversible, their direction depending on the nature of

the environment, and it is quite impossible to show that the complex environment of most Carabidae is such as to favor wing atrophy by selection.

As a modification of the selection theory, it has been suggested that wing atrophy may be advantageous to beetles without regard to ability or inability to fly. For instance, energy may be transferred from the development of wings and wing muscles to more important functions, so that brachypterous individuals may be more efficiently organized. To test this it would be necessary to breed and study dimorphic species in the laboratory, and this has not been done for any Carabidae, but it is suggestive that Jackson (1928) has found, in the dimorphic weevil *Sitona hispidula* Fab., that short winged are more viable than long winged individuals. On the other hand, if brachypterous mutants were less viable than the parent stock, as they usually are in laboratory Drosophila (Pearl 1928), selection would retard or inhibit atrophy.

As another modification of the selection theory, it has been suggested by Lomniki (1898) that wing rudiments may assume a secondary function other than flight of value to the insect, and that selection accordingly may tend to reduce the wings to a certain point and maintain them there. Wing atrophy would then be a change of function rather than a loss of function. This theory was advanced more to explain the remarkable persistence of the wing rudiments of beetles than to account for wing atrophy. There seems to be no evidence for this hypothesis among Carabidae, for, as Oertel (1924) and Maran (1927) point out, there is no reason to think that the wing rudiments, which are hidden under more or less ankylosed elytra, ever do assume a secondary function. The existence of dimorphic species, showing that wings frequently atrophy to small vestiges through single, presumably nonpurposeful mutations, directly contradicts Lomniki's theory, too.

After the theory of natural selection, that of the inheritance of acquired characters, of characters acquired through disuse or through the direct action of the environment, has been most often invoked to explain atrophy of insect wings. Even Darwin (*l. cit.*) suggests that natural selection is probably supplemented by the effect of disuse in causing the atrophy of beetle wings, and as recently as 1927–8 Rüschkamp has adopted a theory of disuse to account for wing atrophy among Chrysomelid beetles. However, I think the evidence is chiefly against theories of use and disuse. In the first place it is hard to see how disuse can affect the dry wing membrane, which is fully developed before it is ready to be used at all, and which is (apparently) not subject to much modification afterward. This objection can be gotten around by supposing that the flying muscles atrophy first and that wing atrophy follows, but this sequence cannot be demonstrated. On the contrary Jackson (1928, 684–5) cites several references showing

[10]The unique winged specimens of *Carabus serratus* and *Micromaseus patruelis* taken on high peaks in the New Hampshire mountains (see p. 154) several miles from the normal lowland ranges of the species probably would have died without being able to mate or reproduce, unless they had done so before straggling to high altitudes. Apparently they are real examples of the action of natural selection in advancing wing atrophy by eliminating flying individuals.

that atrophy of wings and of wing muscles is sometimes not very closely correlated among insects. In the second place, what little experimental evidence there is, drawn from a study of many generations of Drosophila reared under conditions which prevented flight (Lutz 1911, Guyenot 1917, 61) shows no connection between disuse and atrophy of wings. In the third place, the theory that wings atrophy as a result of disuse is opposed by the very existence of numerous dimorphic species in which the short winged forms seem undoubtedly to have originated by mutation, and there is no reason to think that these species do not represent typical stages in the ordinary process of wing atrophy. There is no evidence that mutations themselves are the result of disuse. Of course the Carabidae in which the wings are more or less continuously variable would suggest progressive atrophy through disuse, except that continuous variation of Carabid wings grades into and is probably essentially similar to wing dimorphism (p. 154). Finally, the winged individuals of some of the dimorphic species are known to fly (p. 154) and in these species disuse is at most relative and not absolute, although atrophy has occurred.

A few writers, including Dewitz (1917–20) and Jeannel (1925 and 26) think that, at least in special cases, changes in an insect's environment, through migration or otherwise, may initiate morphological or physiological changes in the wings which eventually are inherited. Dewitz, more specifically, considers that external agencies which retard oxidation within the body may cause wing atrophy, and other writers have suggested that either scarcity or superabundance of food may cause certain kinds of organic atrophy, but none of them tells us how induced atrophy becomes heritable. Among dimorphic Carabidae, where both long and short winged individuals ordinarily occur in the same environment, one can hardly credit the latter with being the cause of atrophy, and if, as has already been suggested, the dimorphic species represent stages through which Carabidae ordinarily pass in losing their wings, the direct effect of the environment, or of physiological changes induced by the environment, apparently must be ruled out. Of course it cannot be proven that insect wings never atrophy through the inheritance of acquired characters, but the evidence against the theory is strong, stronger, thanks to the apparently unadaptable rigidity of the wing membrane and to the occurrence of wing dimorphism, than in most phases of organic evolution.

To avoid possible misunderstanding it may be added that, although physiological changes induced by the environment apparently do not start progressive wing atrophy, nevertheless physiological changes must be bound up with atrophy. A change, however, apparently must be initiated in the germ cell if it is to be heritable. It should not be supposed that changes or mutations occurring in the germ affect the structure of the soma with magical directness. What a mutation does is to cause, in a way not yet understood, a readjustment of the physiological processes of development.[11] Sometimes the readjustment ends

[11]In this connection the conclusions of Harnly (1930) may appropriately be cited. "The mutant gene for vestigial [wings] in *Drosophila melanogaster*, then, not only has varied morphological effects, but also has varied physiological actions."

in the premature death of the organism, and in that case the mutation is a "lethal"; otherwise it results finally in a new or modified characteristic, such as abbreviated wings, in the mature organism. Merely to demonstrate the immediate physiological processes which result in a new character obviously does not bar out the possibility of mutation. For example even if wing atrophy were shown to be a sort of neoteinia (*cf.* p. 151) with a demonstrable physiological basis, that would not mean that mutation might not underlie the whole phenomenon.

A third theory of wing atrophy, differing from both that of natural selection and that of the inheritance of acquired characters, has been championed recently among coleopterists especially by Jeannel, (1923, 1925, 1926), who believes that the process is orthogenetic or determinate and that it is sometimes, especially among cave beetles, only one part of a complex series of orthogenetic changes which include ankylosis of elytra, reduction of pigmentation, loss of eyes, and other less important modifications, some of which have been described on p. 151. Rüschkamp (1927) and other writers have also frequently mentioned orthogenesis as a possible factor in wing atrophy. The theory of orthogenesis rest upon a study of phylogeny rather than on experiment or logic. It is essentially a descriptive statement, that some sorts of evolution have been observably directional and apparently predetermined; it is not an explanation of causes. The causes are usually presumed to be unintelligent,[12] physiological forces lying chiefly within the organism, not in the environment. Of course the finding that the flying wings of Carabidae have tended to atrophy wherever flight is not observably useful agrees well with the theory of orthogenesis, for atrophy might be due to some inherent force or tendency favoring wing degeneration except where prevented by natural selection.

Weismann's (1892) theory of "Panmixia" also was advanced to account for the atrophy of organs. The theory is that parts of organisms tend to atrophy as a result of the indiscriminate interbreeding of less with more fit individuals of a species *after the cessation of natural selection*. Except that Weismann specifically assumed degenerative changes to be gradual (not mutative), his theory fits the present problem well, for atrophy has been found to have occurred chiefly where the usefulness and selective value of wings cannot be demonstrated. Unfortunately, however, his theory, like orthogenesis, boils down to no more than a statement of observation. He believed that he observed degeneration following the cessation of natural selection, but he does not tell why it follows. Panmixia is therefore really no more than a special case of orthogenesis, using the latter term rather loosely. Weismann's attempted explanation, that degeneration is the direct result of random interbreeding among individuals of varying fitness, is incorrect. Genetics does not show that random interbreeding would have any effect except to maintain the average characteristics of a species, unless additional factors were present.

[12]The idea of an intelligence directing evolution has sometimes been employed to account for some characteristics of organic evolution. The idea repells most modern biologists, but Corset (1931) falls back on something very similar to explain the amazing coaptation of different parts of the exoskeletons of insects.

As a matter of fact Weismann himself later (1904) saw the inadequacy of his theory of panmixia and bolstered it with another theory of organic atrophy, "germinal selection." In it he worked out a theoretical system of competing germinal determinants, arranged so an increase or decrease in any determinant would tend to be automatically progressive, which is to say, practically, orthogenetic. If atrophy started for any reason, it would, according to this theory, acquire a sort of momentum within the germ cell which would carry it through. This theory of germinal selection certainly forshadows modern genetics in a general way, but its details are equally certainly wrong. It was inevitable that they should be wrong, for Weismann did not have at his disposal the genetic facts which are common knowledge now.

Some writers refer to "regressive orthogenesis in senile lines," as though the age or senility of a species were a cause of atrophy. Inasmuch as the ancestors of all complex organic life originated many millions of years ago, however, all present day organisms must trace almost equally far back, and there does not seem to be any time during the "origin" of a species from which its age and eventual "senility" can be dated. Perhaps some species are more liable than others to atrophy or decay, and they may have qualities analogous to senility, but this can hardly be the result of old age as we ordinarily understand the term. To call such species senile and to say that they degenerate because of their senility is merely to conceal our ignorance of the real factors involved.

Probably, in fact, no reasonable explanation of orthogenetic wing atrophy has been available until very recently, but today genetics offers one, based on recurrent mutations. Very extensive genetical studies have shown that mutations sometimes recur in identical form time after time in single species and there is no reason why under certain conditions recurrent mutations might not accumulate and eventually change certain characteristics of a species without the action of any other evolutionary process. To make this clear it seems best to state a few facts about mutation which are perhaps not generally known to entomologists.

In the first place mutation may be presumed to have a real physiological basis within the germ cell. The effect of temperature and x-rays upon the frequency of mutations is sufficient proof, if proof is needed. Second, although mutation is "random" in that there is apparently no beneficial correlation between the well being of a species and the sort of mutations which occur, mutation is far from random in another sense. There is something beside chance which causes some mutations to recur as often as once in every 100,000 individuals, while others recur only once in many millions, or perhaps appear only once in the history of a species. So far as can be seen the occurrence of any single mutation in any single individual organism is due largely to chance, but the proportion of individuals in which a recurrent mutation appears is not due to chance but to physiological factors within the species. From a statistical point of view mutation rates are very similar to death rates, in that the death of a single organism (or the appearance

of a single mutant) at a given time depends largely on chance, while the incidence of death (or of mutations) in different classes of individuals is not due to chance but to the characteristics of each class. The sum of the forces which determine the average frequency of a mutation in a given species may conveniently be called the *potential* of mutation, and the potential varies enormously.

The return to wings of Carabidae, the very fact that mutations to a short winged condition have occurred at all (and they have certainly occurred in hundreds of species throughout the world) is evidence that there is at least a slight potential within the germ favoring them, and it is necessary only to suppose that it is sometimes strong enough to cause constant recurrence of mutations to have a possible explanation of orthogenesis in wing atrophy.

Of course even in the most frequently recurring mutations the ratio of mutants to non-mutants is very low. R. A. Fisher (1930, 18–20) says that known mutation rates are rarely as high as 1 in 100,000, and points out that, with a mutation rate of this order, a lapse of time of the order of 100,000 generations would be required to produce an important change with respect to the factor concerned. Fisher shows further that if a mutant character has even a very slight selective advantage, say of 1 percent, so that the mutant individual has an expectation of offspring only 1 percent greater than the non-mutant, evolution by selection should be about a thousand times more rapid than evolution by recurrent mutation as just illustrated, and a very slight adverse selective action eliminating mutants will quickly stop the accumulation of mutations, though not their recurrence. Fisher, and more recently also Haldane (1933) conclude that piling up of recurrent mutations must usually be an insignificant process compared with natural selection. However, in special cases where selective forces are balanced or absent, accumulation of mutations may cause gradual orthogenetic or determinate changes. This is, perhaps, especially likely to occur in atrophy processes, as Fisher (p. 16) concedes in his discussion of Weismann's theories.

It has already been said that the very occurrence of wing atrophy by mutation among Carabidae supports the idea that atrophy may continue by recurrent mutation. The further fact that the progress of atrophy, the increase in proportion of short winged individuals, is very slow is additional favorable evidence. The progress of atrophy almost certainly is slow, for otherwise the chances would be enormously against as many as 14 species in the local fauna being di- or polymorphic at once, at the same instant of geologic time. In such genera as Carabus and Cymindis, in each of which there are several more or less related dimorphic species, it is a question whether the dimorphism is inherited from a common ancestor or has originated by parallel mutation in the different species. Either way the evidence favors the idea of very slow atrophy by accumulation of mutations, for if dimorphism is an ancestral condition, atrophy must at least be of the required slowness, while if brachyptery has originated by equivalent mutations in the different species, there must be a real potential within the germ cells of the genus tending to cause parallel, determinate changes, presumably repeated

within each species as well as in related species. This is especially clear in Cymindis, in which the wing vestiges of the six dimorphic species show little variation.

It is possible, of course, that at least some of the dimorphic species are in a state of equilibrium, with various evolutionary forces so balanced that dimorphism is indefinitely maintained. This might happen if a constant recurrence of brachypterous mutations were opposed by a very slight selective action favoring flying individuals (*cf.* Fisher, pp. 19–20). A condition resembling equilibrium might be maintained if selection favored flying individuals in part of a species' range, flightless ones in another part. A sort of equilibrium might be reached, too, if there were ordinarily an advantage in wing atrophy, so that the proportion of short winged individuals would increase by selection, except during times of environmental fluctuation, when flight might be advantageous in the redistribution of a species (p. 162) so that a certain number of winged individuals would tend always to survive. In such a case there might be an actual advantage in dimorphism itself as compared with either uniformly functional or uniformly atrophied wings. Such a condition among Carabidae might be compared in a very general way to that among ants, most species of which are dimorphic with respect to wings. The winged sexual forms of ants usually distribute the species, and prevent inbreeding, by marriage flights, while the wingless workers are better fitted to carry on most other activities. It is hard to doubt that there is an advantage in wing dimorphism of this sort, and there may well be an advantage also in the dimorphism of Carabidae.

Only one other fact need be noted for the present in connection with atrophy by recurrent mutation—that there is a possibility of reverse mutations from a short back to a long winged condition which might retard atrophy.

The conclusions of the last few pages may be reviewed briefly as follows: granting that mutation is involved, as shown by the dimorphic species, only two supplementary theories have been found which seem worth considering as explanations of wing atrophy among Carabidae. One is that, when a brachypterous mutation occurs, natural selection, either because flightlessness itself is advantageous or because flightless individuals are more viable than others, increases the proportion of brachyptery in successive generations until macropterous individuals are entirely eliminated. A small amount of evidence has been found to show that selection of this sort does occur, but there is certainly no proof that selection is essential in wing atrophy. The other theory which has been found to agree reasonably well with the facts is that of orthogenesis, the cause of which is probably accumulation of recurrent mutations. Other factors may be present but, if so, I do not know what they are. Inheritance of acquired characters does not seem to be among them.

Bearing in mind that all of the probable factors in wing atrophy are at least theoretically reversible, as mentioned in each case above, and that the direction and rate of change is a resultant of all the factors,

we may combine them in the following table, putting first the apparently inescapable fact that at least one mutation is involved in each case:

Opposing Atrophy		*Toward Atrophy*
	(Original mutation, or mutations in polymorphic species)⟶	
⟵(Recurrence of mutations, tending to cause orthogenesis)⟶		
	⟵(Selection of flying or flightless individuals)⟶	
⟵(Selection due to differences in viability, not to flight)⟶		
	⟵(Possible other factors)⟶	

It would probably be impossible even in the laboratory to determine the relative importance of these factors in any given case. It would require extraordinarily painstaking work to demonstrate an average selective advantage of 1 percent in a single species in an artificially stablized environment, while in nature an average selective advantage of even a small fraction of 1 percent, in a variable and constantly changing environment, may be expected to have a profound effect on a species. Fisher (*l. cit.*) may be consulted for a more detailed discussion of this fact. It is remarkable that some able biologists have occasionally missed it completely, and have been guilty of stating that, because they have observed some individuals of a species falling victim to enemies in spite of apparent defensive adaptations, the latter must be of no survival value and cannot have been developed by natural selection. One might as well say that, because armed individuals of *Homo sapiens* sometimes fall victim to predatory animals, fire arms have no survival value. The fact is that selective processes are to be expected to be almost always undetectable in the field, so that no amount of negative evidence can seriously damage the selection theory. There is, perhaps, some justification for believing that, if selection is practically undetectable in nature, it is as much a theoretical phenomenon as the inheritance of acquired characters, but it must be remembered that, unlike the latter, evolution by selection can be artificially stimulated until it is easily observable. The rate of recurrence of mutations and differences in general viability of mutant and non-mutant forms might be determined in the laboratory with proper patience and technique, but even this would be difficult, for even "general" viability depends partly on the environment (Cf. Pearl 1928), and would not give a complete picture of an atrophy process unless selective forces were known.

Although an exact determination of the factors underlying atrophy in any special case seems to be out of the question, something can be said in general concerning their interrelation during the wing atrophy of Carabidae. Presumably brachypterous mutations are constantly occurring as a result of a slight, widely distributed germinal potential. Sometimes, for instance among arboreal and hydrophilous species, selection usually opposes atrophy, short winged mutants are usually eliminated, and the species usually remain functionally winged. In other cases, among island and mountain species according to conventional views, selection favors and accelerates atrophy. In some cases atrophy may be opposed, in others accelerated by differences in general viability of long and short winged forms. In still other cases an

equilibrium of some sort may be approached, maintaining dimorphism indefinitely. But when selective forces happen to be nearly balanced or absent, atrophy probably takes place gradually by orthogenesis, through recurrent mutation.

When the inner wings have become uniformly minute, variation in the exact size of the vestiges probably makes little difference to the insect, and this is probably one of the reasons why the wing vestiges are so persistent. Nevertheless they do gradually become smaller and smaller, for, although there are exceptions, the smallest vestiges usually occur in the species with the greatest secondary modifications for a flightless life, which are presumably the species in which the wings started to atrophy in the most remote past. I think that the most probable explanation of the continued reduction of the wing vestiges is that there is a very slow orthogenetic accumulation of mutations toward, but rarely to, complete atrophy. Perhaps the smaller and less complex an organ becomes, the smaller and fewer the mutations which affect it. Perhaps, too, the last stages of atrophy occur only as a secondary result of the evolution of other organs, which may tend to crowd out the wing vestiges as they evolve, by gradually changing the structure and physiology of the whole organism.

An orthogenetic tendency toward atrophy by recurrent mutation in the absence of selective action seems to account satisfactorily, too, for some of the secondary changes which follow wing atrophy among beetles. Some changes, especially in the shape of the humeri and in the metathorax, seem sometimes to be immediate by-products of the brachypterous mutation (p.153). Otherwise, and even during further atrophy in the structures just mentioned, atrophy probably occurs through accumulation of mutations affecting organs which have lost their function as a result of the loss of functional wings. To take the most striking example which occurs to me, atrophy of wings apparently greatly reduces the value of eyes, which frequently atrophy in flightless beetles. The loss of functional wings, then, by destroying or reducing the usefulness of various other structures, which then atrophy by recurrent mutation, might very well result in such complex series of orthogenetic changes as described by Jeannel and other writers (p. 167).

Since most of the factors governing wing atrophy are theoretically reversible, one might suppose that the atrophy process itself would be reversible, and this is probably the case as long as even an occasional functionally winged individual exists within a species, or as long as there is a possibility that a random combination of factors can revive functional wings, but I cannot agree with Sharp (1903, 197), W. Horn (1907, 464) and others who apparently believe that the entire atrophy process is reversible in nature, that functional wings may be gradually developed from minute rudiments, or even, according to Horn, among beetles in which aptery is primary, not acquired. It must be remembered that in all species in which wing atrophy is long standing numerous secondary modifications occur. If such species were to regain functional wings, they would have not only to regenerate the latter, but to re-evolve a strong metathoracic skeleton, complex flight

muscles, muscles for raising the elytra, which in turn would have to be freed if they had become ankylosed, and presumably instincts to govern the use of this complex apparatus. Apparently all this would have to occur before the structures in question would be of any use to the beetle! It is incredible that such a series of changes could occur, unless one wants to believe that there is intelligence in evolution.

In conclusion I should like for a moment to take a more general point of view than has been possible in the preceding pages. It seems to me that an evolving organism is a complex variable system the form of which at any time is the resultant not only of environmental forces such as selection, but of internal forces too. The external forces are more variable, usually stronger, and much more obvious, so that their importance is usually somewhat exaggerated by evolutionists. Nevertheless internal forces tending not only to limit but to change the organism in certain specific ways do exist. They are revealed partly (but perhaps not entirely) by the very different frequencies of different mutations, and are presumably due to imperfect equilibria existing among the components of the germ cells. The germ is, of course, a complex system in itself, and it would be very remarkable if all its components were equally stable and not liable to modification depending on their nature and relation to other components. Internal forces might be expected to be more constant than external ones, for germ cells obviously change much less rapidly than the environment often does, and this may partly compensate for their relatively low potential, especially over long periods of time.

Conditions and forces within the germ cell presumably play a part in all sorts of evolution, constructive as well as degenerative, both by limiting modification in some directions and by accomplishing it in others, causing some sort of orthogenesis. However, the rôle of internal forces is most obvious in atrophy. Judging from the preponderance of destructive mutations observed in the laboratory, at least some species of organisms would disintegrate rapidly and completely through the action of internal forces if other forces did not prevent it. Ordinarily selection does prevent disintegration. Whenever the usefulness and selective value of a structure disappears, however, internal forces apparently tend to cause the structure to disintegrate or atrophy by repeated mutation, just as they have apparently tended to cause the atrophy of Carabid wings in environments where flight is not obviously of value to the insects. I think, therefore, that Weismann was right in supposing that atrophy tends to occur wherever the forces of selection are absent, and I think the explanation is to be found in the nature of the constituents of the germ, as Weismann was driven to believe in his theory of germinal selection. The theory of germinal selection itself, however, must be replaced by a mutational theory which agrees more closely with the observations of genetics.

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EXPLANATION OF PLATES

PLATE I

Fig. 1, *Cicindela belfragei* Sallé (× about 18); 2, *Omus dejeani* Rche. (× about 20); 3, *Amblycheila cylindriformis* Say (× about 11); 4, *Tricondyla aptera* Ol. (× about 11). Figs. 1 to 4 show lateral view left side metathorax.

Key, Figs. 1 to 4:

A—anterior end	pn—postnotum
w—wing vestige	sp—first abdominal spiracle
mes pn—(mesothoracic) postnotum	abd—abdomen
ps—(metathoracic) prescutum	epm—(mesothoracic) epimerum
scu—scutum	eps—(metathoracic) episternum

5, *Scaphinotus andrewsi* Harr. (× 3.2); 6, *Carabus serratus* Say: (a) outline and vestigial wing of ♀, Cambridge, Mass.; (b) wing of ♂, Mt. Washington, N. H. (both × 3); 7, *Carabus chamissonis groenlandicus* Dej.: ♀, White Mts., N. H. 8, *Carabus sylvosus* Say: ♀, no locality; 9, *Carabus limbatus* Say: ♀, Chicopee, Mass.; 10, *Carabus vinctus* Web.: (a) ♀, "Mass."; (b) ♀, "Conn." Figs. 7 to 10 show vestigial wing and left half metanotum from above, drawn as though insects were all exactly the same size, or had elytral sutures of exactly the same length, as the figured specimen of *Carabus serratus*. 11, *Bembidion muscicola* Hayw.: (a) outline and vestigial wing of ♀, Sherborn, Mass.; (b) wing of ♀, Arlington, Mass. (both × 19).

Key to venation (after Forbes):

c—costa	cu—cubitus
sc—subcosta	a—anals
r—radius	pt—pterostigma
m—media	

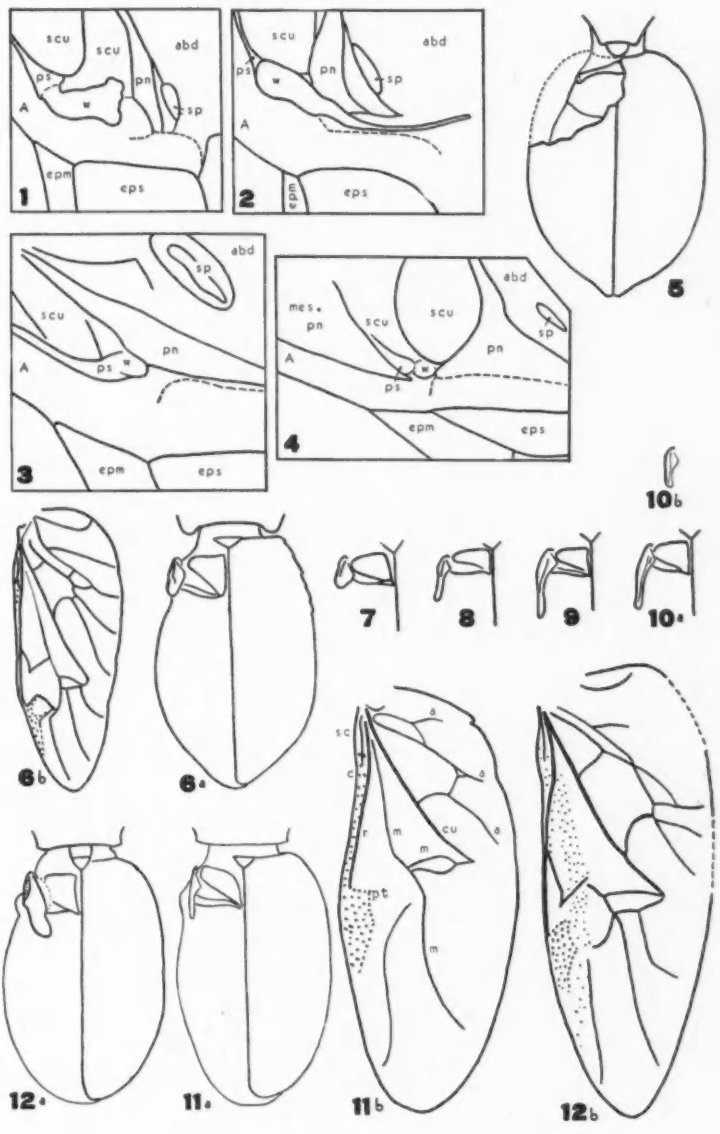
Fig. 12. *Patrobus longicornis* (Say): (a) outline and vestigial wing of ♂, Arlington, Mass.; (b) wing of ♀, Arlington, Mass. (both × 4.8).

PLATE II

Fig. 1, *Micromaseus patruelis* (Dej.): (a) outline and vestigial wing of ♀, Norfolk Co., Mass.; (b) vestigial wing of ♂, Springfield, Mass.; (c) of ♂, Arlington, Mass.; (d) wing of ♀, Springfield, Mass. (all × 9.3). 2, *Micromaseus corrusculus* (Lec.): (a) Outline and reduced wing of ♀, Holliston, Mass.; (b) reduced wing of ♀, Newton, Mass.; (c) of ♀, Lexington, Mass.; (d) of ♂, Lexington, Mass. (spread); (e) of ♀, Tyngsboro, Mass. (outline to show folding) (all × 11.3). 3, *Celia remotestriata* Dej.: (a) Outline and reduced wing of ♀, Cheyenne, Wyo.; (b) reduced wing of ♂, Breckenridge, Col.; (c) of ♀, Breckenridge, Col.; (d) of ♀, Peachland, B. C.; (e) wing of ♀, Cambridge, Mass. (all × 7.7). 4, *Platynus retractus* (Lec.): (a) outline and vestigial wing of ♂, Randolph, N. H.; (b) vestigial wing of ♀, Mt. Washington, N. H.; (c) reduced wing of ♂, Marion, Mass.; (d) of ♂, Tyngsboro, Mass.; (e) wing of ♀, Mt. Moosilauke, N. H. (all × 8.4). 5, *Chlaenius aestivus* Say. (a) Outline and vestigial wing of ♀, "Miss."; (b) reduced wing of ♀, Camden, S. C.; (c) of ♂, Washington, D. C.; (d) of ♂, "La."; (e) of ♂, Amherst, Mass. (spread); (f) wing of ♂, Brooksville, Fla. (all × 3.2).

PLATE III

Fig. 1, *Cymindis cribricollis* Dej.: (a) outline and vestigial wing of ♂, Rangeley L., Me.; (b) wing of ♂, Brookline, Mass. (both × 7.5). 2, *Cymindis pilosa* Say: (a) outline and vestigial wing of ♀, "Mass."; (b) vestigial wing of ♀, "Mass."; (c) wing of ♂, Rumney, N. H. (all × 6.2). 3, *Cymindis borealis* Lec.: (a) outline and vestigial wing of ♀, Damaris Cove Is., Me.; (b) wing of ♀, Edmonton, Alta. (both × 6.9). 4, *Cymindis neglecta* Hald.: (a) outline and vestigial wing of ♀, Dracut, Mass.; (b) wing of ♂, "N. H." (both × 7.6). 5, *Cymindis elegans* Lec.: (a) outline and vestigial wing of ♂, no locality; (b) wing of ♀, no locality (both × 5.9). 6, *Cymindis americana* Dej.: (a) outline and vestigial wing of ♀, Tyngsboro, Mass.; (b) wing of ♂, Rumney, N. H. (both × 5.4).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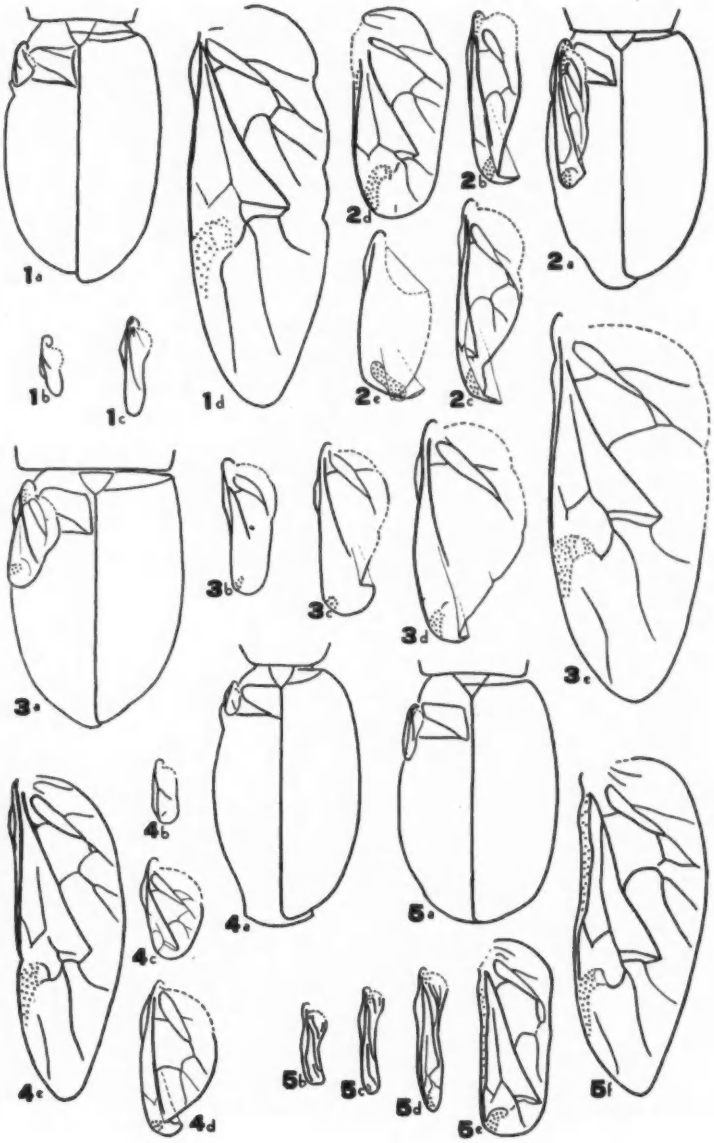
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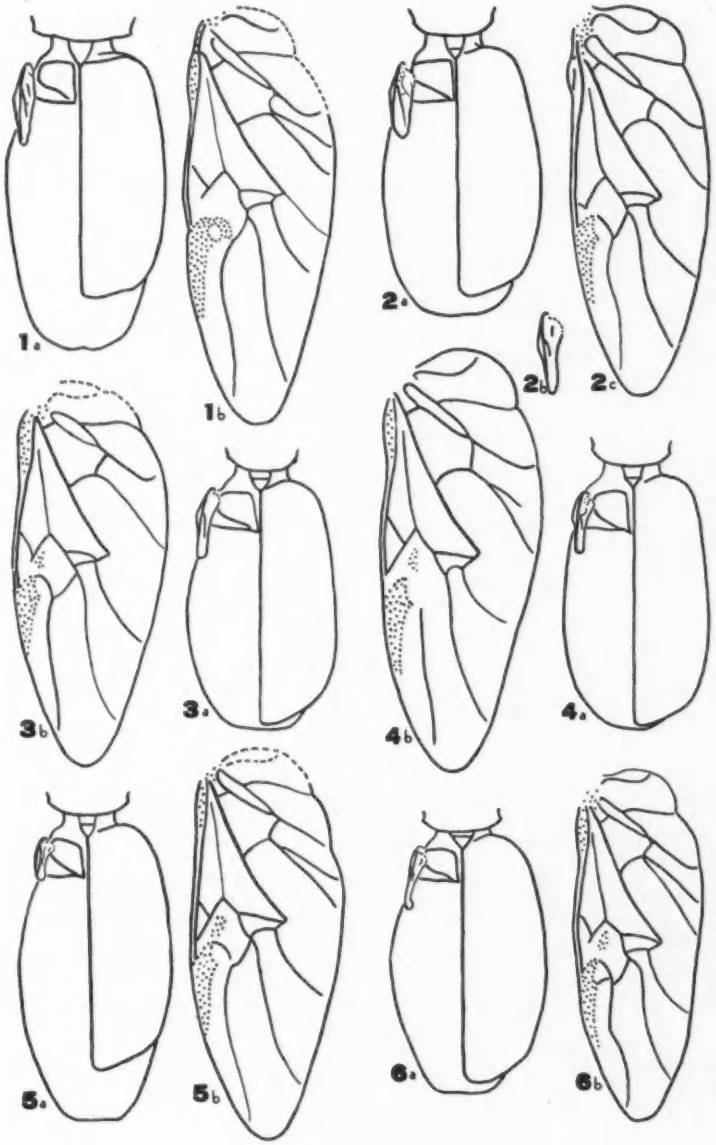
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PROCEEDINGS OF THE THIRTIETH ANNUAL MEETING

St. Louis, Missouri, December 30-31, 1935

The Entomological Society of America held its Thirtieth Annual Meeting on Monday and Tuesday.

The Annual Public Address was given by Mr. Curtis P. Clausen, Federal Bureau of Entomology. His subject was "Insect Parasitism and Biological Control." In this address, Mr. Clausen discussed the history of biological control, the problems involved and the results obtained. A series of lantern slides emphasized in a most interesting way the international movement of insect parasites and predators since its beginning in 1873. The program of papers presented at the two days meeting follows:

Opening Session, Monday Morning, December 30

The Society was called to order at 9:30 A. M. by PRESIDENT C. H. KENNEDY in the Ivory Room of Hotel Jefferson. The following papers were presented:

1. Tarantula Studies. (10 min.) W. J. BAERG, University of Arkansas, Fayetteville, Ark.
2. Tarantulas in Missouri. (15 min.) (Lantern.) L. F. PINKUS, 5714 Rhodes, St. Louis, Mo.
3. A Classification of the Primitive Hymenoptera. (15 min.) (Lantern.) HERBERT H. ROSS, St. Nat. Hist. Surv., Urbana, Ill.
4. New Syrphidae from Brazil. (By title.) CHARLES L. FLUKE, JR., Old Soils Bldg., Madison, Wis.
5. Variations of Seasonal Cycle in the Genus Tabanus. (10 min.) (Lantern.) H. H. SCHWARDT, Department of Entomology, University of Arkansas, Fayetteville, Ark.
6. Some Evolutionary Trends in the Stratiomyidae. (10 min.) (Chart.) MAURICE T. JAMES, Department of Entomology, Colorado State College, Ft. Collins, Colo.
7. A Synopsis of the Nearctic Species of Oschinella and Madiza, Based on a Study of the Types. (Diptera, Chloropidae.) CURTIS W. SABROSKY, Wellington High School, Wellington, Kansas.
8. Life Histories of Certain Beach Burrowing Coleoptera. (10 or 15 min.) (Lantern.) J. K. G. SILVEY, Department of Biology, North Texas State Teachers' College, Denton, Texas.
9. Host Relationship of the Apple Curculio. (10 min.) (Chart.) PAUL O. RICHTER, Department of Economic Entomology, University of Wisconsin, Madison, Wis.
10. Observations on the Biology of *Lygaeus kalmii* Stål. (Hemiptera Lygaeidae). (5 min.) WILLIAM A. SIMANTON, Gulf Research and Devel. Corporation, Susquehanna, Pittsburgh, Pa.
11. Histological Studies of the Digestive System of the Squash Bug, *Anasa tristis* De G. (Hemiptera, Coreidae). (15 min.) (Lantern.) E. P. BREAKEY, Department of Entomology, Ohio State University, Columbus, Ohio.

The following committees were appointed by PRESIDENT KENNEDY:

Nominating Committee—P. W. CLAASSEN, Chairman; H. H. KNIGHT, J. E. ECKERT.

Resolutions Committee—W. D. FUNKHOUSER, Chairman; W. P. HAYES, W. J. BAERG.

Auditing Committee—R. H. BEAMER, Chairman; JOSEF KNULL, B. E. MONTGOMERY.

The Society then adjourned to meet with the American Association of Economic Entomologists to hear the address of their president, MR. LEE A. STRONG.

Second Session, Monday Afternoon, December 30

The Society was called to order by PRESIDENT KENNEDY at 2:00 P. M. and the following papers were presented:

12. The Ant Larvae of the Subfamily Ponerinae. (15 min.) (Lantern.) GEORGE C. WHEELER, University Station, Grand Forks, N. Dak.
13. The Efficiency of Colored Lights in Trapping June Beetles. (10 min.) (Lantern.) A. A. GRANOVSKY, Division of Entomology, University Farm, St. Paul, Minn.
14. Noctuidae at Bait Trap. (10 min.) H. H. WALKDEN, 1204 Fremont Street, Manhattan, Kans.
15. A Study of Fecundity and Fertility in the Blowfly, *Phormia regina*. (10 min.) (Lantern.) ALBERT C. MILLER, 381 W. Ninth Ave., Columbus, Ohio.
16. The Food Plants of the Leafhoppers of the Genus Agalliopsis. (10 min.) E. D. BALL, Exp. Sta., University of Arizona, Tucson, Arizona.
17. The Food of Insects in Relation to Resistance of Plants to Insect Attack. (15 min.) (Lantern.) REGINALD H. PAINTER, Department of Entomology, State College, Manhattan, Kansas.
18. Studies in the Incubation of the Chinch Bug. (10 min.) M. J. JANES, Texas Experiment Station, Winter Haven, Texas, and ANNA HAGER.
19. Studies on Temperature and Moisture as Factors Influencing Winter Mortality in Adult Chinch Bugs. (12 min.) (Lantern.) GEORGE C. DECKER and FLOYD ANDRE, Department of Zoology, Iowa State College, Ames, Iowa.
20. The Effect of Parasitic Sting on the Respiration of the Mediterranean Flour Moth Larvae (*Ephestia kuehniella* Zeller). (15 min.) (Lantern.) NELLIE M. PAYNE, Department of Entomology, University of Minnesota, University Farm, St. Paul, Minn.
21. A Pressure Apparatus for Producing Artificial Atmospheres of Known Composition in Physiological Studies. (10 min.) (Lantern.) D. F. MILLER, Department of Zoology, Ohio State University, Columbus, Ohio.
22. Growth Curves for *Blattella germanica*. (10 min.) (Lantern.) LAURENCE C. WOODRUFF, University of Kansas, Lawrence, Kans.
23. Dragonflies as a Food of Birds. C. H. KENNEDY, Ohio State University, Columbus, Ohio.
24. A Review of the Dragonflies of the Genera Neurocordulia and Platycordulia. (By title.) C. FRANCIS BYERS, Department of Biology, University of Florida, Gainesville, Fla.

PRESIDENT KENNEDY appointed the following fellows to act as alternates for absent members of the Executive Committee, which met immediately following the afternoon session: WILLIAM A. RILEY, T. H. FRISON, WILLIAM B. HERMS.

Third Session, Tuesday Morning, December 31

The Society was called to order at 9:30 A. M. by PRESIDENT KENNEDY and the following papers were presented:

25. The Dimorphic Blue Female of *Everes comyntas*. (10 min.) (Lantern.) EDWIN P. MEINERS, 6600 Delmar Blvd., St. Louis, Mo.
26. The Genera and Genotypes of Tingitoidea of the Western Hemisphere. (5 min.) C. J. DRAKE and M. E. POOR, Iowa State College, Ames, Iowa.
27. A Primer for the Aphid Hunter. (5 min.) F. C. HOTTES, James Millikin University, Decatur, Ill.
28. A Synopsis of the Sub-Family Issinae (Fulgoridae) North of Mexico, with Descriptions of Some New Species. (5 min.) (Lantern.) KATHLEEN C. DOERING, Department of Entomology, University of Kansas, Lawrence, Kans.
29. The Genus Dicyphonia (Homoptera, Cicadellidae). (15 min.) (Lantern.) R. H. BEAMER, Department of Entomology, University of Kansas, Lawrence, Kans.
30. A Study of the Male Genital Characters of the Genus Draeculacephala (Homoptera, Cicadellidae). (10 min.) (Lantern.) DWIGHT M. DELONG and RALPH H. DAVIDSON, Ohio State University, Columbus, Ohio.
31. A Study of Some Groups of Thamnotettix (Homoptera, Cicadellidae). (10 min.) (Lantern.) DWIGHT M. DELONG, Ohio State University, Columbus, Ohio.
32. The Skin Texture of Some Agrotid Larvae. (15 min.) (Lantern.) JOHN H. HAWKINS, Agri. Exp. Station, Orono, Me.
33. The Insect Fauna of Cured Tobacco. (15 min.) (Lantern.) E. M. LIVINGSTONE and W. D. REED, 3303 Floyd Ave., Richmond, Va.
34. The Seasonal History of *Phylloxera notabilis* Pergande on Pecan (Phylloxeridae, Homoptera). (10 min.) (Lantern.) F. E. WHITEHEAD, Agricultural College, Stillwater, Okla.
35. Records of Southern Insect Species Moving Northward During the Drouth Years of 1930 and 1934. (5 min.) HARRY H. KNIGHT, Department of Zoology, State College, Ames, Iowa.
36. The Problem of Races of *Anopheles quadrimaculatus* in the United States. (By title.) E. HAROLD HINMAN, Department of Tropical Medicine, Louisiana University, New Orleans, La.
37. Notes on the Ragweed Borer (*Epiblema strenuana* Walk.) and its Parasites. (10 min.) (Chart.) PAUL L. RICE, Department of Zoology and Entomology, Ohio State University, Columbus, Ohio.
38. The Effect of Different Varieties of Sorghums and Other Host Plants on the Biology of the Chinch Bug (*Blissus leucopterus*). (15 min.) (Lantern.) R. C. DAHMS, R. O. SNELLING, F. A. FENTON, Department of Entomology, Oklahoma A. & M. College, Stillwater, Okla.

Fourth Session, Tuesday Afternoon, December 31

Following the call to order at 1:30 P. M. by PRESIDENT KENNEDY, the following papers were given:

39. Honeybee Monstrosities. (5 min.) J. E. ECKERT, Box 381, Davis, Calif.
40. The Relations of Insects and Plants in Gall Production. (15 min.) (Lantern.) E. P. FELT, Bartlett Tree Research Lab., Stamford, Conn.
41. Observations on Possible New Evidence for Homologies in Wing Venation of the Diptera. (10 min.) CORNELIUS B. PHILIP, Rocky Mountain Laboratory, Hamilton, Mont.
42. A Morphological Analysis. (10 or 15 min.) (Lantern.) PHILIP LEVEREAULT, Department of Entomology, University of Kansas, Lawrence, Kans.
43. The Permanent Preservation of Insects. (15 min.) WALTER WORMSER, 602 East Springfield Ave., Champaign, Ill.
44. The Role of Insects in the Conservation Program. (10 min.) LEONARD HASEMAN, University of Missouri, Columbia, Mo.

The above meetings were attended by about 200. There were, however, only 112 who signed the attendance cards that were so thoughtfully provided by the local arrangements committee.

Fifth Session, Tuesday Evening, December 31

Following the entomologists' dinner, PRESIDENT C. H. KENNEDY introduced MR. CURTIS P. CLAUSEN, who gave an illustrated address on "Insect Parasitism and Biological Control."

The following is a report of the Annual Business Meeting which was held Tuesday afternoon, December 31:

REPORT OF THE SECRETARY

During the year 1935, the following having been duly nominated and recommended, were elected members of the Society by mail ballot of the Executive Committee:

BARNARD DE WITT BURKS, 1209 W. Illinois St., Urbana, Ill.
LAWRENCE SAMUEL DILLON, 1502 Center Ave., Reading, Penn.
ROY HENRY NAGEL, Div. Ent., University Farm, St. Paul, Minn.
LESLIE W. ORR, Bureau of Ent., Federal Bldg., Milwaukee, Wis.
L. C. PAUL, Dominion Entomological Lab., Saskatoon, Sask., Canada.

With the approval of the Executive Committee, CURTIS P. CLAUSEN was invited to give the Annual Public Address of the Society at the St. Louis meeting.

DOCTOR LEONARD HASEMAN kindly consented to act as Chairman of the Arrangements Committee for the St. Louis meeting.

The Executive Committee met at 4:30 P. M., December 30, in the Hotel Jefferson, St. Louis, Missouri, the following officers being present: C. H. KENNEDY, W. T. M. FORBES, H. B. HUNGERFORD. One other member of the committee was present: ALVAH PETERSON. The following alternates, designated by the President, served in place of absent members of the committee: WILLIAM B. HERMS, WILLIAM A. RILEY, T. H. FRISON.

The Executive Committee unanimously nominated J. G. NEEDHAM for Honorary Fellow and he was elected by the Society. The Executive Committee elected the following Fellows: KATHLEEN C. DOERING, S. GRAENICHER, A. GRANOVSKY, C. L. FLUKE, S. W. FROST, J. A. HYSLOP, C. E. MICKEL, A. J. MUTCHLER, R. H. PAINTER, A. G. RUGGLES, H. H. SCHWARDT, JAY R. TRAVER, L. C. WOODRUFF.

The following were elected to membership in the Society:

H. L. BARRETT, JR., 307 College Ave., Arlington, Texas.
JAMES EVERETT BUSSART, 318 East Indiana Ave., Wheaton, Ill.
JOHN S. CALDWELL, Biological Survey, Ohio State University, Columbus, Ohio.
PHILIP G. COUTRE, 73 Baldwin St., Laconia, N. H.
RICHARD HENRY DAGGY, 482 So. Pt. Douglas Road, St. Paul, Minn.
OLIVE FALLS, Terminix Division, E. L. Bruce Co., Memphis, Tenn.
LI FENG-SWEN, Division of Entomology, Univ. Farm Campus, St. Paul, Minn.
WILLIAM D. FIELD, 325 Indiana St., Lawrence, Kans.
ELIZABETH G. FISHER, Comstock Hall, Cornell University, Ithaca, N. Y.
RICHARD T. HOLWAY, South Duxbury, Mass.
ARTHUR PAUL JACOT, Appalachian Forest Exp. Station, Asheville, N. C.
HARRY E. JAQUES, 709 N. Main St., Mt. Pleasant, Iowa.
HAROLD C. JONES, Dept. of Biology, Berry College, Mount Berry, Ga.
MYKOLA H. HAYDAK, Ent. Div., University Farm, St. Paul, Minn.
JOHN D. MAPLE, Univ. of Calif. Citrus Exp. Station, Riverside, Calif.
HSIEN-CHEN MA, Division of Ent., Univ. of Minnesota, St. Paul, Minn.
ABE E. MICHELBACHER, 112 Agriculture Hall, Univ. of California, Berkeley, Calif.
STANISTAW MINKIEWICH, Dept. of Ent., Gov. Inst. for Agric. Research, Pulway, Poland.
WILLIAM D. MURRAY, Entomology Dept., Minnesota Univ., St. Paul, Minn.
THEUNIS JOHANNES NAUDE, Chief Entomologist, Dept. of Agric., Union of South Africa, P. O. Box 513, Pretoria, Union of South Africa.
RENAUD PAULIAN, Licencie es Sciencies, 9 rue, Auguste Lancon, Paris XIIIe, France.

HAROLD J. PAULLUS, Fredericktown, Mo.
LAWRENCE R. PENNER, 706 Conn. St., Lawrence, Kans.
L. F. PINKUS, 5714 Rhodes Ave., St. Louis, Mo.
JANUS E. RIDLEY, Dept. of Ent., Univ. Farm, Univ. of Minnesota, St. Paul, Minn.
FRANK ROBERT SHAW, Fernald Hall, Massachusetts State College, Amherst, Mass.
WILFRED SHOCKLEY, Darby, Montana.
CLYDE F. SMITH, Research Asst., Utah Exp. Sta., Logan, Utah.
FRANK K. SMITH, 420 W. Twenty-first St., Pueblo, Colo.
HOWARD WEEDON SMITH, Box 21, New Ipswich, N. H.
WILLIAM C. STEHR, Dept. of Biology, Ohio University, Athens, Ohio.
FORREST BROOKS WHITTINGTON, B. & Z. Bldg., Ohio State Univ., Columbus, Ohio.
WILLIAM WILD, 249 Walnut St., East Aurora, N. Y.
CHIA HSIEN YEN, Div. of Entomology, University Farm, St. Paul, Minn.

The total number of new members for 1936 is 38.

The following have resigned during the year: C. W. CREEL, A. C. COLE, IRENE D. DOBROSCKY, H. L. DOZIER, CRAIG W. EAGLESON, JOHN M. ENBURG, G. L. GARRISON, R. M. GEIST, GEORGE HENDRICKSON, P. H. HERTZOG, WILLIAM A. HIESTAND, HOWARD E. HILLEMANN, YIN-CHI HSU, S. J. HUNTER, D. W. JONES, THOMAS B. KERN, H. H. KING, GEORGE A. MALONEY, C. E. OLSEN, L. C. PAUL, R. H. PETTIT, H. K. PLANK, JEAN PIATT, P. B. POWELL, HAZEL W. RIDDLE, R. L. ROUDABUSH, R. C. SHOTWELL, J. P. SLEESMAN, A. N. SOLBERG, ALFRED TAYLOR, L. S. WEST, W. W. YOTHERS.

The following have been automatically dropped from membership either because of failure for three or more years to pay dues or because they cannot be reached: A. W. ANDREWS, C. S. BANKS, H. E. BELL, L. J. BENNETT, W. G. BRUCE, MADIMORE BRUNSON, MRS. GERTRUDE B. CHAFFEE, S. W. CLARK, F. D. DEGANT, K. A. HAINES, CECIL HART. E. A. HERR E. C. HODSON, W. B. HOLLINGSWORTH, C. H. JOHNSTON, C. B. MAYER. G. A. MCNALLY, V. S. L. PATE, G. L. PHILLIPS, C. T. RAMSDEN, M. M. REEHER, BERNARD SEGAL, J. A. SMITH, E. H. P. SQUIRE, B. F. STEELE, W. A. THOMAS, W. L. THOMAS, S. H. WILLIAMS.

The following were elected to the Editorial Board for the term expiring December 31, 1938: WILLIAM B. HERMS, WILLIAM T. M. FORBES, C. T. BRUES.

The Executive Committee voted $50.00 toward the support of Biological Abstracts for 1936.

The Executive Committee voted to publish the membership list.

The Executive Committee recommended to the Society that $500.00 be transferred from the Savings account for the use of the Annals. This was passed by the Society in accepting the report.

DOCTOR NATHAN BANKS presented a proposal to the Executive Committee that a committee be set up to consider plans for sponsoring a loan library of separates to be housed at some convenient institutional library. He generously offered his private library as a nucleus for such a library. After some discussion in which it was pointed out that it was not the policy of the Society to maintain a library, that it had never accepted exchanges, that the responsibility of a library might eventually at least involve some financial burden upon the Society, the committee decided that it was inadvisable to sponsor this worthy undertaking.

The Executive Committee adjourned at 6:45 P. M.

The Society has suffered the loss by death of the following four members: F. M. ROOT, JAMES HANSEN, H. E. MCMILLAN and PAUL MARTIN.

REVEREND JAMES HANSEN, a charter member of the Society, was born at Jacobs Prairie, Minnesota, July 25, 1874, and died July 19, 1934, at Collegeville, Minnesota, where he was a teacher in St. John's University.

He received his training in St. John's and was ordained a priest in the Benedictine Order June 11, 1901. Because of a severe attack of tuberculosis which destroyed one lung, he was assigned to one of the Minnesota Missions to build up his health. Here he devoted himself to collecting plants and insects and so far recovered his health that he returned to St. John's University in September, 1902, to teach Botany and Greek. Here he made a collection of several thousand species of insects. Father James was a jovial man, popular with his students and beloved by his colleagues. His wide knowledge of nature was an inspiration to those who knew him.

DOCTOR FRANCIS METCALF ROOT was born at Oberlin, Ohio, September 24, 1889. He attended Oberlin College, where he received the A. B. degree in 1911 and the M. A. in 1912. He received his Ph. D. from Johns Hopkins in 1917 and became teaching fellow of medical entomology in the School of Hygiene and Public Health in 1919. From this position he advanced to associate professorship in 1926. Doctor Root was a special student of flies and mosquitoes and co-author of the text book, "Animal Parasitology," by Hegner, Root and Augustine. He published a number of papers on mosquitoes, some of them resulting from a trip he made to Brazil in 1925. He died October 21, 1934. Doctor Root's sudden and untimely death from heart disease was a severe loss not only to Johns Hopkins University, but to the science of Medical Entomology as well.

H. ELLIS MCMILLAN joined our Society in 1934 and word has reached us that he died this year. He was employed as Assistant Entomologist, Dominion Entomological Laboratory, Lethbridge, Alta., Canada. His experimental work was with cutworms. He received his M. S. degree in 1930 from the University of Saskatchewan.

DOCTOR PAUL FERDINAND MARTIN, who joined our Society in 1931, was born in the city of Dresden (Saxony), on July 15, 1884. He was graduated from the University of Saxony in Veterinary Medicine and specialized in the diseases of the horse. He went to Peru, South America, in 1913, where he was employed as Bacteriologist and Veterinarian by the "Casa Gildemeister, Hacienda Casa-Grande, Valle de Chiama-Urujillo." In 1919 he went to Lima and for six years was the Municipal Veterinarian and veterinarian of President Leguia. He was also the official veterinarian of the jockey club and of the Plaza de Toros de Acho.

In his later years he devoted much time to the study of Entomology, giving his attention especially to the Coleoptera and Lepidoptera of the rain forests of Peru. At his untimely death on August 13, 1935, he had accumulated a large collection of these insects. He was also a member of the Royal Entomological Society of London.

Following the reading of these brief memorials, the members stood in silent respect of these men lost to the Society through death.

Respectfully submitted,

H. B. HUNGERFORD, *Secretary.*

REPORT OF THE TREASURER

CURRENT FUNDS

RECEIPTS

Balance in Bank, December 31, 1934 (See Annals XXVIII, p. 180)	$1,223.21
From Annual Dues of Members to December 28, 1935	2,481.07
Received from C. H. Kennedy, Managing Editor Annals	520.00
Total	$4,224.28

EXPENDITURES

Fifteen hundred three-cent Stamped Envelopes	$ 49.14
Union of American Biological Societies for Support of Biological Abstracts	50.00
Printing Letterheads and Envelopes for President and Secretary-Treasurer	7.50
W. E. Britton, One-half Expenses to Attend Meeting of Committee on Advancement of Official Entomology at Penn Hotel, New York, February 9, 1935	2.17
Edward's Bros., 1,000 Copies of Report on International Organization of Zoologists (sent to J. C. Bradley)	20.90
Spahr & Glenn Printing Co., Printing December, 1934, Annals, March, June, and September, 1935, Annals	2,496.56
Life Membership Fee of E. Gorton Linsley Transferred to Permanent Fund	50.00
Printing Preliminary Announcements, Blank Forms, and Programs	56.00
Bank Service Charge and Exchange Charge on Checks	13.19

Clerical Services	25.00
One thousand one and one-half cent Stamped Envelopes	16.92
Printing two Rubber Stamps	.60
Total	$2,787.98
Balance in Bank	1,436.30
	$4,224.28

LIABILITIES

The Society owes the publishers for the December, 1935, Annals. Of the above cash receipts for dues, $1,056.00 is for 1936 dues.

PERMANENT FUND

In Savings Account of People's State Bank, Lawrence, December 31, 1934	$3,026.34
Payment of One Life Membership	50.00
Four Liberty Bonds Turned into Savings Account: (B-00911757, C-04921513, D-04921514, H-048969)	200.00
Payment by J. J. Davis on Loan to Thomas Say Foundation	100.00
Interest on Bonds for Year	7.66
Interest on Savings for Year	60.59
In Savings Account of People's State Bank, Lawrence, December 28, 1935	3,444.59
One Liberty Bond (45554-D)	50.00
	$3,494.59

RESOURCES

Liberty Bond (45554-D)	$ 50.00
Savings Account	3,444.59
Balance in Checking Account	1,436.30
Total	$4,930.89

In addition to the above, the Thomas Say Foundation is in debt to the Society to the extent of $200.

Respectfully submitted,

H. B. HUNGERFORD, *Treasurer.*

On motion the Treasurer's Report was accepted, subject to the approval of the Auditing Committee.

REPORT OF THE MANAGING EDITOR OF THE ANNALS

I wish to report that 519 pages of matter have been published in Volume 28 for 1935, as against 637 pages in the volume for 1934.

With the present income of the Society, which appears to be nearer stability than for 1934, the Society probably can expect a volume of four hundred or five hundred pages for 1936. Enough manuscript is already on hand to fill a volume of such a size.

The Managing Editor wishes to thank MR. BIRELY J. LANDIS and MRS. ELIZABETH A. DAVIS for very faithful service.

The financial summary follows:

RECEIPTS

Non-member Subscriptions	$ 686.30
Sale of Back Numbers	94.61
From Authors for Cuts	501.67
From Authors for Printing Costs	48.00
Bank Balance from 1934	2.28
	$1,332.86

EXPENDITURES

To Engravers	$ 437.72
Office Help	219.48
Postage	94.07
Miscellaneous	55.62
To Secretary	523.00
	$1,332.86

Vouchers have already been submitted and approved by the Auditing Committee.

Respectfully submitted,

CLARENCE H. KENNEDY, *Managing Editor.*

On motion, the report was adopted subject to the approval of the Auditing Committee.

REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION

FOR THE YEAR 1935

RECEIPTS

Balance on hand, December 1, 1935	$149.45
Received from 1934 Sales	9.00
1935 Sales of Volume 1 (1 copy)	3.00
1935 Sales of Volume 2 (6 copies)	25.50
1935 Sales of Volume 3 (9 copies)	31.20
Total Receipts	$218.15

EXPENDITURES

Payment on Loan to Entomological Society of America	$100.00
Commission to C. C. Thomas for Sale of Two Books	1.00
Express and Postage on Volumes Sold	3.01
Miscellaneous Postage	1.00
Total Expenditures	$105.01
Balance in Purdue State Bank December 21, 1935	113.14
	$218.15

There is a balance due the Entomological Society of America of $200.00. Also a total of $23.40 is still due the Foundation for two copies of Volume 2 and four copies of Volume 3, payment for which has not yet been made.

Respectfully submitted,

J. J. DAVIS, *Treasurer.*

On motion the report was accepted subject to the approval of the Auditing Committee.

REPORT OF THE AUDITING COMMITTEE

We, the undersigned members of the Committee on Auditing, beg to report that we, after careful examination of the books of the Treasurer, the Managing Editor of the Annals and the Treasurer of the Thomas Say Foundation for the year 1935, have found them to be correct and properly balanced.

Respectfully submitted,

R. H. BEAMER, *Chairman,*
JOSEF KNULL,
B. E. MONTGOMERY.

On motion, the report of the Auditing Committee was accepted.

REPORT OF THE NOMINATING COMMITTEE

The Nominating Committee hereby submits the following nominations for the offices of the Society for 1936:

President—H. B. HUNGERFORD
First Vice-President—J. A. HYSLOP
Second Vice-President—T. H. FRISON
Secretary-Treasurer—C. E. MICKEL
Two Members of Executive Committee to Serve until 1938—W. A. RILEY and W. D. FUNKHOUSER.
Councillors to the American Association for the Advancement of Science—W. B. HERMS and O. A. JOHANNSEN.
One Member of Joint Committee on Insect Collections of America, to Serve until 1938—C. P. ALEXANDER.

Respectfully submitted,

P. W. CLAASSEN, *Chairman*,
H. H. KNIGHT,
J. E. ECKERT.

On motion the report was accepted and the Secretary instructed to cast a ballot for the election of the persons nominated. This being done, they were duly elected.

REPORT OF THE JOINT COMMITTEE ON INSECT COLLECTIONS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA AND THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Last year for the first time committees on insect collections for the Entomological Society of America and the American Association of Economic Entomologists reported as a single or joint committee. Since the data for private collections are published by the American Association of Economic Entomologists, only the data concerning institutional collections are included in this report. Reports from institutional collections totaled sixteen in 1933, twenty-four in 1934, and twenty-three have been submitted this year.

Last year your joint committee suggested that probably after a period of a few more years, there would be very few private collections of importance which had not been reported to the committee and that a report on private collections might lapse for a few years until a new group of private collectors had been developed. Only eight reports from private collectors were submitted this year and your committee is recommending to the American Association of Economic Entomologists that no effort be made to secure information on private collections for a period of several years because results from this type of activity for the next two or three years are certain to be negligible. In spite of this recommendation we feel, however, that the American Association of Economic Entomologists should continue its committee on insect collections to act jointly with the committee of the Entomological Society of America whenever possible and necessary in order to insure or aid the better protection, development and study of insect collections in this country and Canada.

Although fewer institutions reported this year than last the report from institutions should be continued without interruption, because every year some important or outstanding additions are made to institutional collections throughout this country and Canada.

Again, as in the report for last year, your committee notes the rapidity with which important insect collections are developing in various parts of the country and that the increase in personnel employed in the identification, arrangement and preservation of this material is not increasing in a proper proportion.

By action of the presidents of both societies, T. H. Frison has served as chairman of this joint committee.

Respectfully submitted,

J. H. McDUNNOUGH, (Entomological Society of America),
C. F. W. MUESEBECK, (Entomological Society of America),
F. E. LUTZ, (Entomological Society of America),
E. C. VAN DYKE, (American Association of Economic Entomologists),
H. H. KNIGHT, (American Association of Economic Entomologists),
T. H. FRISON, *Chairman*, (American Association of Economic Entomologists).

The American Museum of Natural History, New York, N. Y.: The collection of insects and spiders was increased in 1935 by about 80,000 specimens, largely from neotropical regions. The Templeton Crocker Expedition to the South Pacific secured about 4,000 specimens. The most notable proportionate growth has been in the collection of nearctic spiders, including large gifts from Dr. W. J. Gertsch and Mr. Peter Steckler.

FRANK E. LUTZ, *Curator*

Brigham Young University, Provo, Utah: The chief addition to the collections in 1935 came as a result of the purchase of the Charles Schaeffer weevil collection. This collection contains about 5,000 specimens composed of 813 species, 21 of which are represented by cotype specimens. Between 3,000 and 4,000 specimens were also added as a result of a faunistic study which is being made at Mt. Timpanogos, Utah.

The University collections are now housed in the new fireproof George H. Brimhall Life Science Building, where adequate room for expansion and research is provided. All the type specimens in the collection are properly labeled and a list of all type species contained in the collection on June 1, 1935, has been published.

VASCO M. TANNER, *Head of Department of Zoology and Entomology*

Canadian National Collection, Ottawa, Canada: The most important additions made to the collection during the past year resulted from faunal surveys carried on by the Entomological Branch. Surveys were undertaken in Nova Scotia, British Columbia, in the Ottawa District of Ontario, and in the Eastern Arctic. About 10,000 specimens were taken, chiefly Lepidoptera, Ephemeroptera, Coleoptera, and parasitic Hymenoptera. The collection now contains type material of 4,063 North American species.

J. McDUNNOUGH, *Chief, Division of Systematic Entomology*

Clemson Agricultural College, Clemson, South Carolina: The collection totals about 34,000 specimens of which 26,000 are identified. This is the result of a joint faunistic survey project carried on by all members of the staff. A card index file is kept which shows geographical and seasonal occurrence of every species identified from the state. The collection is principally representative of the southeastern area, mainly restricted to the South Carolina fauna. Our file now shows 5,059 species of insects known to occur in this state, as follows: Orthoptera and related groups, 189; Hemiptera, 337; Homoptera, 462; Neuroptera and minor orders, 315; Lepidoptera, 576; Coleoptera, 1,800; Diptera, 788; Hymenoptera, 592.

DAVID DUNAVAN, *Assistant Professor of Entomology and Zoology*

Colorado State College of Agriculture and Mechanical Arts, Fort Collins, Colorado: Our insect collection has been increased during the past year by the addition of approximately 15,000 pinned specimens and 104 aphid slides. About 5,000 specimens have been identified by various specialists. Our most concentrated work has been in the orders Diptera and Hymenoptera, which have been increased by more than 200 species new to the collection; though considerable additions have been made to our Neuroptera, Ephemeroidea, and Homoptera, and minor ones to several other orders. Our housing facilities have been increased to the extent of about 160 boxes.

MAURICE T. JAMES, *Curator of the Museum*

Illinois State Natural History Survey, Urbana, Illinois: About 25,000 pinned specimens were added to the collection here in 1935; 15,000 of these were leafhoppers, representing the second year's drive in the survey of these for Illinois. The remaining 10,000 specimens were miscellaneous. Approximately a thousand vials of aquatic material was collected; almost all of it represented Trichoptera,

Plecoptera and Ephemerida. Types of 20 Plecoptera, 6 Symphyta, 4 Sialidae and 1 Cecidomyiidae were added. Bird and mammal ectoparasites have been taken throughout the year.

HERBERT H. ROSS, *Systematic Entomologist*

Iowa State College, Ames, Iowa: Only small additions have been made to the insect collection during the past year. These number approximately 3,000 specimens, mostly from Iowa, including some 350 named species.

HARRY H. KNIGHT, *Curator*

Iowa Wesleyan College, Mount Pleasant, Iowa: The insect collection includes about 30,000 insects, practically all from Iowa. These are housed in steel cabinets. The collection is available to other workers.

H. E. JAQUES, *Head of Department of Biology*

Kansas State College of Agriculture and Applied Science, Manhattan, Kansas: Last year there were no noteworthy additions to the college collection. We would place the increase in the neighborhood of 2,000 specimens.

ROGER C. SMITH, *Professor of Entomology*

Montana State College, Bozeman, Montana: There has been an addition during the year of approximately one thousand specimens of Montana insects. Approximately two hundred species, determined by various authorities, have been added to the Montana Hemiptera and Collembola. The most important changes in our collection this year have been in consolidation and reorganization, and determination of an abundance of material already on hand.

HARLOW B. MILLS, *Assistant State Entomologist*

Museum of Comparative Zoology, Cambridge, Massachusetts: Last year I noted that the Wheeler collection added 30,000 specimens; now a count shows that it added over 80,000. The Museum collection of Formicidae is now arranged in 260 boxes and comprises 110,766 specimens, representing 4,900 named forms. The unarranged material includes nearly as much more.

Mr. Bates collected and pinned over 16,000 moths at Barro Colorado Island, Central America; many others were in papers, and from Honduras and the Bay Islands many thousand more, as well as many miscellaneous insects. All have been pinned, labelled, and part spread. Professor Forbes, of Cornell is now working over the Arctiidae of this collection. Mr. Bates' West Indian material has also been mounted and the butterflies named. Mr. Clench brought back from Cat Island, Bahamas, about 2,000 insects. Dr. Wheeler obtained about a thousand on his visit to Guatemala and Panama.

Mr. N. A. Weber terminated his year's research on Trinidad and the Museum benefits by several thousand ants and 2,000 miscellaneous insects.

Mr. E. W. Thompson gave 2,800 Mexican beetles, the Boston Society gave 2,000 small Diptera from Cuba, Professor Brues gave over 1,000 small Hymenoptera from Foochow, China, and Doctor Bequaert has given parts of his Diptera collection.

The Director purchased a general collection from eastern Brazil containing 4,000 insects. Mr. Darlington, with the aid of a volunteer worker, Mr. S. Williams, has been able to make great progress in the Coleoptera. The Loveridge African material has been labelled and often remounted, the West Indian and Central American largely arranged, and collector labels have been placed on the Gehring collection.

The Curator has had the opportunity to work over the Neuroptera collected by the Australian Expedition in 1932, and by Mr. Clagg in Mindanao in 1930. There are now types of 22,000 species of insects catalogued.

NATHAN BANKS

North Dakota State College, Fargo, North Dakota: Approximately 4,200 specimens were acquired this year. Of these 2,000 were by donations or purchase and about 2,200 from faunistic surveys.

J. A. MUNRO, *State Entomologist*

Ohio State University, Columbus, Ohio: During 1935 we have added 377 insect drawers to our permanent equipment. This will give us a total of 877 drawers for housing our collections.

During the year, we had a number of additions to our insect material. Dr. R. C. Osburn has donated an extensive collection of North American and exotic Syrphidae which he has been accumulating for many years. There are numerous types included in this material. Prof. Herbert Osborn has added many Hawaiian

Cicadellidae, including many types recorded in his paper, "Cicadellidae of Hawaii." Dr. C. H. Kennedy has donated an extensive collection of North American Hymenoptera which he has gathered for some time. Over 10,000 southwestern insects were added by the curator.

J. N. KNULL, *Curator*

Oregon Agricultural College, Corvallis, Oregon: The committee wishes to clarify a misstatement which occurred in the report for this institution last year. The report stated that Professor H. A. Scullen donated 70,000 to 100,000 specimens to the college collection. Mr. Scullen writes us that these represent the collections of all the members of the entomological staff in addition to his own.

Royal Ontario Museum of Zoology, Toronto, Ontario: The insect collection is one of the largest in Canada, but at the present time it is in process of being rearranged and catalogued. It is not possible to give any definite indication of the number of specimens contained in it.

J. R. DYMOND, *Director*

University of British Columbia, Vancouver, British Columbia: The collections of this institution are in a formative condition, consisting of a large amount of unidentified material. The following items are of the greatest interest.

Lepidoptera—The Blackmore collection, consisting of 10,000 specimens, comprising 843 species of Macros and 495 species of Micros. Mallophaga—42 species plus over 400 unidentified collections. Anoplura—22 species. Siphonaptera—28 species, of 61 recorded for the province. Orthoptera—95 species, and Dermaptera 5, all native to British Columbia.

The more general collection includes 600 named species of Coleoptera, 117 species of Hemiptera-Homoptera, 14 boxes of Hymenoptera, and 16 of Diptera, both unidentified.

G. J. SPENCER. *Department of Zoology*

University of Idaho, Moscow, Idaho: The collection includes approximately 30,000 specimens, about 20,000 of which are determined. The determined material represents species distributed as follows: Orthoptera, 91; Isoptera, 3; Neuroptera, 16; Ephemerida, 6; Odonata, 14; Corrodentia, 4; Homoptera, 259; Hemiptera, 165; Neuroptera, 1; Coleoptera, 956; Lepidoptera, 213; Diptera, 567; Hymenoptera, 2. Acquisitions during the past year include about 5,000 specimens collected by students and members of the staff.

The entire collection has been placed in steel cabinets and in the unit tray system during the past year.

W. E. SHULL, *Associate Entomologist*

University of Kentucky, Lexington, Kentucky: During the past year the collection was increased by approximately 1,000 specimens, either collected by the staff of the Division of Entomology or sent in by students and correspondents.

M. L. DIDLAKE, *Associate Entomologist and Botanist*

University of Minnesota, St. Paul, Minnesota: Approximately 22,000 insect specimens have been added to the collection during the year. Mr. C. N. Ainslie, of Sioux City, Iowa, has presented the collection with an additional 7,000 specimens, most of which are determined. The most important purchases added to the collection were 900 determined European specimens, 505 specimens determined ants, and 127 Arizona Mutillidae. Approximately 1,500 specimens of determined Mutillidae were added to the Minnesota collection in return for determinations made for various institutions and individuals. Among the specimens added to the collection last year were approximately 6,200 specimens of Minnesota insects. A beginning has been made toward cataloging the entire collection. At the present time, about 10,000 entries have been made in the catalog and these entries cover approximately 15,000 specimens. Material from the University collection is available to responsible students making a study of any particular group.

C. E. MICKEL, *Associate Professor of Entomology*

Utah State Agricultural College, Logan, Utah: During 1935, approximately 1,600 slides of Utah, Idaho, and Colorado aphids were added to the Knowlton collection. Approximately 4,500 pinned specimens have been added to the Utah Experiment Station collection, consisting largely of Homoptera, Orthoptera, Hemiptera, Diptera, and Coleoptera. During the year a number of workers have aided by identifying material. Approximately 25 per cent of the Experiment

Station collection is now identified. Faunistic surveys dealt largely with range, forage, and truck crop infesting species.

G. F. KNOWLTON, *Associate Entomologist*

United States National Museum, Washington, D. C.: Approximately 116,000 specimens were acquired during the year. The only notable accessions have been the Beutenmuller collection of 3,848 galls and 4,551 gall wasps; the Townsend collection of 4,133 muscoid flies assembled by Dr. C. H. T. Townsend during his service for the Peruvian Government and transmitted by them to the U. S. National Museum on the basis of exchange; the Bovie collection of 30,000 weevils purchased and donated by Mr. L. L. Buchanan; the Guthrie collection of 579 slides of Collembola, donated by Mrs. Guthrie; the collection of 5,000 miscellaneous insects made in the Far East by Mr. T. R. Gardner, of Moorestown, New Jersey; the usual accession of specimens (this year 47,000) from the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture. New additions to the type series amounted to about 500 species.

E. A. CHAPIN, *Curator, Division of Insects*

Bernice P. Bishop Museum, Honolulu, Hawaii: Insect collections accessioned since November, 1934, are as follows: Small collection from American Equatorial Pacific Islands (Palmyra, Jarvis, Howland, Baker, Swains), collected by E. H. Bryan, Jr., and other members of three Itasca Expeditions. Good collection from Hawaii, obtained by R. L. Usinger and other members of the Hawaiian Academy of Sciences Mauna Kea Expedition, August, 1935. A few specimens collected on Wake Island by Pan American Airways personnel.

Practically all of the specimens from Samoa, sent for identification in co-operation with the British Museum (Natural History), in the preparation of "Insects of Samoa" have been returned, giving Bishop Museum an extensive, well determined series of Samoan insects. Most of the specimens from the Marquesas and Society Islands, collected by the Pacific Entomological Survey, which had been sent to specialists for identification, have been returned and published upon. Mangarevan Expedition specimens are being sent out for study.

The Museum's card catalog of insects recorded from Pacific Islands has been kept up to date, and sections have been published as Occasional Papers, after revision by systematists, as follows: C. P. Alexander, Tipulidae (IX: 21); R. H. van Zwaluwenberg, Elateridae (IX: 23); J. C. Chamberlin, Pseudoscorpions (X: 22); R. Kleine, Brenthidae (XI: 1); F. Ohaus, Rutelinae (XI: 2); K. Friedrichs, Embiidae (XI: 7); W. M. Wheeler, Ants (XI: 11).

E. H. BRYAN, JR., *Curator of Collections*

The Francis Huntington Snow Entomological Museum, University of Kansas, Lawrence, Kansas: During the season of 1935, about 4,000 specimens of exotic Aquatic Hemiptera have been received. These came from England, Australia, Mexico and South America.

The additions of North American insects are as follows: total number of specimens, 64,307; total number of species, 1,326; total number new to the collection, 496; total number represented by types, 101.

Dr. R. H. Beamer and party, including two students, made an extended collecting trip through the western states, covering some 9,600 miles and obtaining many interesting species.

H. B. Hungerford and Milton Sanderson collected in Michigan, the latter bringing back many Coleoptera to enrich the Museum collection in that order.

H. B. HUNGERFORD, *Curator*

REPORT OF THE COMMITTEE ON RESOLUTIONS

1. WHEREAS, the success of the Thirtieth Annual Meeting of The Entomological Society of America has been due largely to the excellent work of the joint committee on arrangements of The Entomological Society of America and the American Association of Economic Entomologists,

Therefore, be it Resolved, that the thanks of the Society be extended to this joint committee and particularly to Professors Leonard Haseman and George D. Jones, the chairmen, for the excellence of their arrangements for our meetings and entertainment.

2. WHEREAS, the Society has learned with sorrow of the deaths of Paul Martin, James Hansen, H. E. McMillan, and F. M. Root the past year,

Therefore be it Resolved, that we express our deep regret at the loss of these members, that we extend our sincerest sympathy to their families and that a copy of this resolution be spread upon our minutes.

3. WHEREAS, the affairs of our organization have been so splendidly administered by the officers of the Society during the past year,

Therefore be it Resolved, that the Society express its appreciation and thanks to the president, vice-presidents, secretary-treasurer and members of the executive committee for their faithful and efficient services.

4. WHEREAS, the Jefferson Hotel has provided excellent facilities for our meeting in St. Louis,

Therefore be it Resolved, that the thanks of the Society be expressed to the management of this hotel for the courtesies and hospitality extended.

Respectfully submitted,

W. D. FUNKHOUSER, *Chairman*,
W. P. HAYES,
W. J. BAERG.

REPORT OF THE COMMITTEE ON ADVANCEMENT OF OFFICIAL ENTOMOLOGY

Doctor E. F. Phillips gave a brief report in which his committee recommended the discharge of the present committee and the appointment of a new committee to consist of three members, the first committee to be appointed as follows: One member to serve for one year, another for two years and a third for three years, and that hereafter, vacancies on the committee be filled by three-year appointments.

The joint Committee appointed as follows: E. F. PHILLIPS, *Chairman*, Ithaca, N. Y., for three years; T. J. HEADLEE, New Brunswick, N. J., for two years; W. P. FLINT, Urbana, Illinois, for one year.

REPORT OF A COMMITTEE TO CONSIDER THE POSSIBILITY OF PUBLISHING A GLOSSARY OF ENTOMOLOGICAL TERMS

Your committee, appointed by President Metcalf after the Pittsburgh Meeting, to make a preliminary study of the feasibility of the preparation of a glossary of entomological terms, having in mind the probability of a revision of the J. B. Smith Glossary, begs to report that H. L. Parker and H. D. Smith, of the Bureau of Entomology Laboratory at Hyeres, Var. France, have such a work in progress concerning which they have written the committee that:

"It was our intention at first to publish a single volume of terms in three languages, English, French, and German. We soon saw that this could not be done at once owing to the confused state of English terms. We therefore decided to get out first a glossary in English using Smith's (J. B.) Glossary as a base, with the intention of converting it later into a trilingual glossary if time and the demand warranted it.

"The English part is barely started, and working evenings only as we are obliged to do, we do not expect to complete it before two years. At present we are waiting for Snodgrass' new book on Anatomy before going any further, as nothing can be done by anyone until it appears.

"We have done so far, I might say, only enough to acquaint us with the enormity of the task and it is not our intention to enter into 'competition' with any person or group in this matter. If no one else takes it up (your committee, for example), we shall go ahead with it, but if it is taken up seriously by some other group or persons, we shall desist (for the English part) and eventually publish the French and German parts, using the production of that group as a base of our work.

"Our projected revision of J. B. Smith was planned to cover all fields of Entomology."

In the opinion of the Committee, there is little doubt but that a full and complete glossary is highly desirable and, in fact, quite necessary. Such a work will need the co-operation of specialists in all taxonomic units, as well as in the various fields of morphology, physiology, ecology, parasitology, embryology and economic entomology. Messrs. Parker and Smith have advertised for help in the columns of some of our American entomological journals (See the *Journal of Economic Entomology*, December, 1935) asking that lists of terms be sent to them.

In order to facilitate the publication of this work within the contemplated two years, this committee recommends that members of the Society and especially those members who were interested enough to seek the appointment of this committee, supply these workers with lists of terms from their various fields of specialization. It is further recommended that this work be made, not the development of a single system of terms but should contain as nearly as possible all entomological terms, good, bad, obsolete and modern, for it is felt there is a need for definitions of all terms whether they were published 100 years ago or recently. Furthermore, we deem it highly desirable that there be added to each definition given, as far as possible, the name of the author, place and year, from which the definition is taken, so that anyone consulting the Glossary for a word used many years ago, could ascertain the probable use of the word at that time. It is therefore urged that all members do their part in assisting the authors to make it complete and useful. The Committee is prepared, if the Society so desires, to furnish the President or the Secretary a list of American specialists in the various fields whom, it is felt, could be asked to supply Messrs. Parker and Smith with lists of terms and definitions in the various specialties. If this report is adopted, a copy of it will be sent to Messrs. Parker and Smith, asking them if they wish such help and if they do, it is recommended that the Society, in some manner prescribed by the President, ask these specialists to serve in this capacity.

It is the feeling of the committee that publication of such a glossary might be undertaken by the Thomas Say Foundation, in the expectancy that the sales would be much greater than has been the case with the other publications of the foundation, and that the expense of publication would likely be covered by receipts in a relatively short time.

Respectfully submitted by

P. P. Calvert,
B. B. Fulton,
Wm. P. Hayes, *Chairman*

REPORT OF THE SEVENTH AMERICAN SCIENTIFIC CONGRESS

The Seventh American Scientific Congress held in Mexico City from September 8 to 17, 1935, under the auspices of the Ministry of Education of the Mexican government proved to be a great success if judged by attendance and the number of papers presented in the biological section. This section of the Congress was very well organized by its chairman, Professor Isaac Ochoterena, director of the "Instituto de Biología" of the National University of Mexico. A total of 33 papers was presented during the four morning and five afternoon sessions that were held. Seven of these papers and one motion picture pertained to entomology. All of the papers were read in Spanish or English.

It has been planned to publish all of the biological papers in both Spanish and English in a special number of the "Anales del Instituto del Biología." When this is published it can probably be procured from Professor I. Ochoterena, Instituto de Biología, Casa del Lago (Chapultepec), Mexico, D. F.

In résumé it can be said that these meetings were successful in bringing together most of the biological workers in Mexico. It is to be hoped that more advanced notice will be given for future congresses in order that more scientists from other countries can attend and give such gatherings a truly Pan American aspect.

C. C. Plummer,
Official Delegate of the Entomological Society of America

REPORT OF THE DELEGATE TO THE SIXTH INTERNATIONAL CONGRESS OF ENTOMOLOGY

The Sixth International Congress of Entomology met at Madrid, Spain, on the 6th to the 12th of September, 1935. In spite of unsettled conditions in Europe and despite the fact that Madrid is out of the usual tourist route, there were over four hundred members registered and a large percentage of these was in attendance.

Considering the distance from the home base, the United States and Canada were well represented by twenty members. Unfortunately there was a conspicuously small representation of Germans, Italians and Russians, who have been prominent in previous sessions.

The Congress was presided over by the Nestor of Spanish entomologists, Professor I. Bolivar Urrutia. Details of organization and of providing for the comfort of visiting members were cared for largely by the son, Professor C. Bolivar y. Pieltıen, Secretary General of the Congress. To these noted entomologists and their associates must be accorded the highest praise for the perfection of organization which marked this session of the International Congress of Entomology.

The numerous sectional meetings were well attended and offered an excellent, though somewhat limited program of papers. Due to the fact that a number of these were presented in Spanish and in Portuguese, as well as in the more customary French, German and English, the printed pages of the Proceedings will have the appeal of novelty for many who heard the original reading. It may be noted that the publication is being prepared in record time.

Interspersed with the scientific, was a remarkable program of entertainment provided by the local committees and by official sources. From the opening session, presided over by the President of the Republic to the closing banquet our hosts established a precedent which will be difficult to maintain. Receptions by the President of the Republic, the Minister of Education and by the City of Madrid, visits to art galleries, cathedrals and castles, and an all-day collecting trip monopolized all of the available time.

A very gracious feature of the program was the bestowal of honorary doctorates by the University of Madrid. The distinguished entomologists so honored were Professor M. Caullery, University of Paris; Dr. R. Goldschmidt, Director of the Kaiser-Wilhelm Institute; Dr. R. Jeannel, Museum of Natural History; Mr. B. P. Uvarov, Imperial Institute of Entomology; and Dr. F. Silvestri, Portici. The last mentioned was on his return trip from South America and unable to reach Madrid.

Altogether, the Sixth International Congress of Entomology was voted a great success by all who were so fortunate as to be present. The Seventh session will be held in Berlin, in 1938, under the presidency of Dr. E. Martini.

Respectfully submitted,

WM. A. RILEY

Following the transaction of the above business, the meeting adjourned.

The following exhibits were on display in rooms near the meeting place of the Society:

1. Food Plants of Grasshoppers. E. D. BALL, Experiment Station, University of Arizona, Tucson, Ariz.
2. Differential Growth of the Grasshopper Body. (Charts.) NELLIE M. PAYNE, Department of Entomology, University of Minnesota, University Farm, St. Paul, Minn.
3. Permanent Preservation of Insects for the Teaching Collection. WALTER WORMSER, 602 East Springfield Ave., Champaign, Ill. and W. P. HAYES, Department of Entomology, University of Illinois, Urbana, Ill.
4. Improvements and New Equipment Used in the Study of Insects. RICHARD LEWIS POST, Department of Entomology, Ward's Natural Science Establishment, Rochester, N. Y.
5. Insectariums. L. F. PINKUS, 5714 Rhodes, St. Louis, Mo.

Respectfully submitted,

H. B. HUNGERFORD, *Secretary.*

BOOK NOTICES

APPLIED ENTOMOLOGY, AN INTRODUCTORY TEXT-BOOK OF INSECTS IN THEIR RELATIONS TO MAN, by H. T. FERNALD. Third Edition. Pages i-x, 1–405, 384 illustrations. 1935. Published by McGraw-Hill Book Company, Inc., New York and London. Price, $3.50.

Since Professor Fernald's retirement as Emeritus Professor, Massachusetts State College, he has lived at Orlando, Florida, where he has had ample time and good facilities (the Federal Entomological Laboratory) for such activities as the present revision of his well-known text-book.

This is the text usually used where the teacher wishes to organize economic entomology along the lines of systematic entomology rather than along those of the host relationships. "Much of this edition has been rewritten to bring the book up to date and quite an amount of it is entirely new. In other parts, changes have been made for the purpose of expressing the facts more clearly." Besides being a conscientiously written text from the pen of one who has had long experience in research and in the training of entomologists it is almost the only good text at a price that the usual agricultural college student can afford to pay. Since the depression, when even graduate students have been reduced to dish-washing and chores, merely to keep fed, the price of a text-book has become a serious matter. Shall we block such students from further study, provide text-books for them or what? Fortunately insects did not cease their damages to restricted crops during this period so that minor positions in entomology are opening up again.

We like to see standard texts revised from time to time. They thus become a living part of entomological training. Incidentally they hold the field and prevent the intrusion of hastily written and more ephemeral works. We congratulate Professor Fernald on this edition of his very useful text.—C. H. K.

LES ANOPHELES DE LA FRANCE ET DE SES COLONIES, 1re PARTIE, FRANCE, CORSE, AFRIQUE, MADAGASCAR, LA REUNION, by G. SENEVET. Pages 1-361, figs 1–140 and 45 plates. 1935. Volume XIX of the ENCYCLOPEDIE ENTOMOLOGIQUE published by Paul Lechevalier et Fils, 12 Rue de Tournon, Paris VIe. Price (paper bound), 95 francs ($5.70).

Doctor G. Senevet, Chief of the Laboratory of the Pasteur Institute of Algeria, in this work gives us the first volume of a larger work on the Anopheline mosquitoes of France and her colonies. It is strictly a key to the species, their distribution and habits. The data on each species is arranged very methodically under blackface subheads. The following are those for *maculipennis* Meigen: Synonymy; Adult, Male; Female; Male Hypopygium; Larva; Pupa; Egg; Varieties; Geographic Distribution; Climatic Conditions; Habitat of Larva; Temperature of Water; Purity of Water; pH Optimum; Migrations of Larva; Associated Species; Length of Aquatic Life; Season of Activity; Number of Generations Annually; Hibernating Form; Distance of Flight; Hosts; Time of Feeding; Domesticity; Role as Vector. Forty-five species and subspecies are thus treated, each with numerous illustrations of anatomical details of larva, pupa and adult.. The last forty pages are devoted to keys to the larvae, pupae and adults of the Anopheline mosquitoes known from France and each of the several African colonies. Thus as stated in the introduction, the work is for the easy identification of mosquitoes by medical men and other colonial officers. In using the book one turns first to the keys given to the species for his particular part of *l'empire francais*, then the general index refers him to the text where he can check his results on the minute descriptions and numerous illustrations of specific characters.

The text is thoroughly documented and thus brings together what is known of the biology of each of the forms treated. It is applied taxonomy, if there is such a form of entomology. Apparently it is extremely useful to medical men in Africa and to students of tropical mosquitoes in general.—C. H. K.

LES ARACHNIDES (SCORPIONS, ARAIGNEES, ETC.), by LUCIEN BERLAND. Pages 1-485, figs. 1-634. 1932. Volume XVI of the ENCYCLOPEDIE ENTOMOLOGIQUE published by Paul Lechevalier et Fils, 12 Rue de Tournon, Paris VIe. Price, paper-bound, 150 francs ($9.00).

This volume is another work that is fascinating to any biologist interested in all the vagaries of evolution of form and habit in a major group of successful animals. It is one of the books we have placed on our list of things to be enjoyed in detail the next time our physician convinces us that we should rest in his hospital. The only books of the same interesting type with which it can be compared are the general works on the structure and habits of ants by such writers as Forel and Wheeler.

The material is treated under the following chapter headings (translated): I. Generalities concerning the Arachnids; II. The Scorpions; III. The Solifugids; IV. The Pseudoscorpions; V. The Ricinulei; VI. The Palpigradids; VII. The Pedipalpids; VIII. The Spiders, Form and Appearance; IX. The Spiders and the Environment; X. The Life of Spiders; XI. The Spiders, Systematic; XII. The Geographic Distribution of Spiders; XIII. The Phalangids; XIV. The Mites and Ticks; XV. The Linguatulids; XVI. Fossil Arachnids; Appendix. The Capture and Preservation of Arachnids.

The sections devoted to taxonomy cover the world fauna and give keys down to family groups. The work is in no manner limited to the spiders of France; in fact it does not even list these. Those parts on Arachnids other than spiders are brief while about three hundred and fifty pages are devoted to the structure, habits and distribution of spiders. Every general aspect of the biology of spiders is touched upon except that of internal anatomy. So much ground is covered that some subjects are too briefly treated. One such is the section on the enemies of spiders. (An Epeirid spider lays about 1,000 eggs which indicates an enormous mortality much of which is from various enemies.) A considerable section is devoted to spider venom. Some of the interesting sections are those on the uses made of silk, the mating habits, social spiders, marine spiders (on coral reefs, etc.) and the curious cases of mimicry. (It is startling to open the volume and see a figure of what appears to be an ant with four pairs of legs. Lacking wings they can mimic but a few insect forms.) There is even a discussion of spider music with illustrations of stridulating organs.

We are disappointed in the one page given over to the Associations of Spiders as unpublished studies in America indicate that spiders are as specifically distributed ecologically as are insects. Actually there is much more ecology than appears as such, for the author discusses cave spiders, ground spiders, tree spiders, flower spiders, wandering spiders, aquatic spiders, etc.

Doctor Berland has written for us one of the very interesting books in the field of the structure and habits of Arthropods. We recommend it to all those entomologists who enjoy straying beyond the strict bounds of their science.

—C. H. K.

ÉTUDE BIOLOGIQUE DES COCCIDES DU BASSIN OCCIDENTAL DE LA MÉDITERRANÉE, by A. BALACHOWSKY. pp. 1-214, I-LXXI, text figs. 1-46 and Pls. I-VII, 1931. Vol. 15 of the Encyclopédie Entomologique published by Paul Lechevalier & Fils 12 Ruede Tournon, Paris VIe. Price, 75 francs ($4.50) paper-bound.

Since about nineteen hundred the Coccidae of southern France and Algiers have had a continuous study by various French entomologists. The initial work was lead by Paul Marchal and in later years by P. Vassyiére and the author of the present volume. The studies of Balachowsky centered on the Coccidae of Algiers, but since his appointment as Director of the Entomological Laboratory at Paris have been extended to the Coccidae of France proper. Southern France and Algiers are dry areas wherein are found a coccid fauna which includes various highly specialized genera. It is a particularly attractive area to coccidologists. The present volume is a summary of this extended study and includes many interesting items from the work in Italy, in Egypt and by Bodenheimer in Palestine.

The volume is largelv biological in the broadest sense. It is divided into four studies. The first is a biogeographic study of the endemic and the introduced

species in northern Africa. This summarizes all available distributional data, and is illustrated with maps and charts. The second study is ecological with discussions of food plants, climatic factors, etc. The third is on the parasites of the Coccidae. The fourth and final part is taxonomic, a list of North African species and a list of the species of southern France including the French Alps, the Rhone area and Corsica.

In the introduction the author justifies his extended discussion of non-economic species. "It is very difficult to understand the habits of economic species, if one does not know those of the wild species; to be willing to ignore general problems in order to devote one's self exclusively to economic problems is not intelligent, bringing one invariably to a negative result. Being ignorant of this principle many, desirous of becoming agricultural entomologists, have produced no contribution of interest to agricultural science and their names have rapidly sunk into mediocrity."

We recommend this volume as an excellent review of a highly specialized group of insects many of which are serious pests. It is so broadly biological that it should be interesting reading for graduate students who wish to improve their knowledge of the French language.—C. H. K.

PROCEDURE IN TAXONOMY, INCLUDING A REPRINT OF THE INTERNATIONAL RULES OF ZOOLOGICAL NOMENCLATURE WITH SUMMARIES OF OPINIONS RENDERED TO THE PRESENT DATE, by E. T. SCHENK AND J. H. MCMASTERS. Pages i-vii and 1-72. 1936. Stanford University Press, Stanford University, Calif. Price, $2.00.

This handy volume is the product of a symposium on taxonomic principles organized by graduate students and professors at Stanford University. "It was prepared for the purpose of supplying the student as well as the professional systematist with (1) a clear-cut and comprehensive statement of the principles of taxonomy; (2) the International Rules of Zoological Nomenclature; (3) Summaries of Opinions Rendered to the present date; (4) a complete index—the only index of the Rules and Summaries ever published."

The original matter is included in twenty-four pages of discussion under the title "Procedure in Taxonomy" and in the sixteen-page "Index." The discussion is divided under the following heads: I. Introduction; II. Systematic Categories; III. Types; IV. The Description of New Species; V. Specific Names; VI. Synonymy; VII. Storage of Type Material; VIII. Latin Terms and Abbreviations. The discussions have a strong flavor of palaeontology from which branch of science the majority of examples are chosen. Some minor divergencies from usage in entomology occur but on the whole the discussion is broad-minded. The reviewer would wish to have found some propaganda for the compulsory illustration of new species, but if propaganda is present in the brief discussion, it is not easily recognized as such.

The text is beautifully printed on excellent heavy paper and is given a solid binding in linen. We are glad to see a reprint of the Rules and Opinions, as the various reprints are more often out of print than not.—C. H. K.

THE BIOLOGY OF MAYFLIES, by JAMES G. NEEDHAM, JAY R. TRAVER and YIN-CHI HSU. Pages i-ix, 1-759, 40 plates (*frontispiece* colored) and 168 text cuts, the majority with several to many figures. Published by the Comstock Publishing Company, Ithaca, N. Y. Price, $7.50.

As this volume is in eight point and ten point type it is equal in amount of contents to a volume of twelve hundred or more pages printed in larger type. As it is the first serious review of North American mayflies it has required years of labor, and that of several persons. The American workers continuously interested in Ephemeridae have been Nathan Banks, James G. Needham, J. McDunnough and Jay R. Traver. Two of these, Needham and Traver, are responsible as authors while the other two (as stated in the introduction) have assisted with material and have been in constant contact with help on the many technical questions that have arisen. This team-work gives assurance of the technical excellence of the work.

The volume is in two parts, "Mayflies in General" (pages 1-236) in which habits and structure are discussed, and "Systematic" (pages 237-739) devoted to descriptions and keys to the 507 species. Part I is a series of eighteen lengthy chapters, much of which appears to have been written by the senior author. However, Chapter VII, Eggs and Oviposition, is by Osgood R. Smith; Chapters II-VI, on Anatomy and Post-embryonic Development, are by Yin-Chi Hsu, while Chapters XI and XII, on the Structure of the Thorax, are by Velma Knox. Traver is largely responsible for the 500 pages of Part II, "Systematic." An easily overlooked foot-note on page 235 states that "descriptions of new species (forty-eight in number), are all written by Dr. Jay R. Traver, and in all future references to them they are to be accredited to her." We hope that the Zoological Record does not overlook this foot-note. That journal may have to change its editorial system to use it. To prevent future trouble in references Dr. Traver should have inserted her name between the name of such new species and the indicator "n. sp."

Part I is the most extensive discussion of the biology and structure of mayflies that has appeared to date. It is well arranged, well balanced and well illustrated. Among the portraits of students of the group we are glad to see the genial face of Rev. A. E. Eton, who was the first scientist to take mayflies seriously. After having struggled at various times to define sclerites in the soft, leathery thorax of the adult mayfly, we are glad to see the chapters on anatomy. That on eggs is interesting with plates of eggs of many curious types, eggs with honey-comb sculpturing, eggs with warts and pimples, hairs and threads and even mushroom-like caps.

Part II has some innovations. The usual keys are used for families, genera and species but with them are "Verification Tables" that tabulate characters, particularly size and color characters. Many of the species are illustrated by sketches of male genitalia, by sketches of the hind wing, the nymphal head, etc.

We have not space for more comments. The work has opened wide the study of North American mayflies. It is a credit to the authors and their University.

—C. H. K.

DAS TIERREICH, 64 Lieferung. LEPIDOPTERA, BARONIIDAE, TEINOPALPIDAE, PARNASSIIDAE pars I, von FELIX BRYK, 1934 *and* 65 Lieferung. LEPIDOPTERA, PARNASSIIDAE pars II (Subfam. PARNASSIINAE) von FELIX BRYK, 1935. Part I, pp. i-xxiii, 1-131 and figs. 1-87. Part II, pp. i-li, 1-788 and figs. 1-698. "Das Tierreich" edited by R. Hesse, published by Walter de Gruyter & Co., Berlin and Leipzig. Price, Part I, RM 25 ($10.00), Part II, RM 110 ($44.00).

These Lieferungen of "Das Tierreich" form one of the most thorough monographs in that distinguished serial on systematic zoology. The three families of butterflies are treated in searching nordic thoroughness. Only fifty species are covered but these are dealt with in all their known forms and described aberrations. For instance, under *Parnassius mnemosyne* L. 115 forms are described, while under *P. apollo* L. are 167 forms and 36 aberrations. The work is minutely documented to an extent that the list of literature abbreviations used occupies twenty-one pages. Keys are used to the species but the lower forms are made accessible by taxonomic grouping, geographic grouping and elaborate indices. The work is printed on excellent paper which carries very well the numerous halftones of the many forms figured. Each illustration has in the legend besides the scientific name and its author, the sex, whether original, and if not, from where copied and the magnification which is usually natural size. A very large number of the illustrations are directly from types. (We wish all figures in taxonomic literature were so carefully documented.)

Biologically the study is strictly limited to the taxonomy of adult forms. Not even food plants are mentioned. Locality data are ample but discussions of distributional problems and the usual interesting speculations on speciation are absent. The only feature approaching this type of matter are the lists, one for each genus, giving the species of that genus which are associated in each of the geographic areas recognized by Lepidopterists. Thus the work as a study of speciation does not approach in biological quality the studies of Goldschmidt on

Porthetria (*Lymantria*) *dispar* or some of the recent American work on the genetics of North American genera of Lepidoptera. The work is purely taxonomic in the older use of the term.

From the point of view of the amount of work by the author and the thoroughness and excellence of his product the two volumes are well worth the price, but from the point of view of printing costs we cannot see the necessity of such a high price. Authors publishing in German journals are usually paid a nominal price for each manuscript but even deserved pay to the author cannot necessitate such prices on publications. A work of this kind is machine made and should have volume production, reasonably low cost and a world-wide market among biological institutions When the publisher can send a gratis copy of a fifty-dollar work for a notice which would be gladly given for five dollars cash, something is wrong. Values are surely out of line. The individual German publishing firms suffer as much under this highly artificial set up as do the individuals and institutions that would otherwise purchase their products. Probably the majority of these famous and honorable firms need our sympathy rather than our criticism.—C. H. K.

MICROENTOMOLOGY

We give this new entomological serial a vigorous gesture of welcome, nevertheless we are perturbed. It is the first serial publication in this field to be printed by the recently developed photolith process.

The Natural History Museum of Stanford University has just issued (January 27, 1936) under this title Number 1 of Volume I, which issue starts a serial wherein each article will appear as a separate number. It will be devoted to studies on material in the Natural History Museum of Stanford University, particularly to studies in those groups of small insects which the student usually mounts on slides and observes under the compound microscope. Coming from Stanford University such a statement in the foreword refers to the large collections of Anoplura, Mallophaga, Coccidae and other minute insects built up by Professors Vernon L. Kellogg and G. F. Ferris.

From the bottom of the last page we quote the printer's mark, "Typing Manuscript and Photolith Reproduction by Stanford University Press." The appearance of "Microentomology" from this responsible source, which in the past has sponsored only the highest press-work, means that the photolith process has reached that degree of excellence where certain types of the more dignified university publications can be brought out by photolith. This relatively cheap process has reached, in skilled hands, that degree of quality where small editions can be produced in a style for which the author and the publisher need not explain or apologize.

The foreword states that by this process illustrations can be reproduced at no more expense than that of text. The present issue is an article by G. F. Ferris on Coccidae, which is illustrated with ten figures of the parts of these insects. The drawings are as well reproduced as if done by zinc etchings in the pages of the "Annals." This is a victory for Professor Ferris, who has always maintained that after the price contributed in the arduous work of drawing, the author should not be asked to pay for the making of cuts.

The photolith process still has some as yet unsolved problems before its perfection to where it will meet the full approval of press experts. The text is gray. The ends of lines are irregular, as it is still a typewriter process and short lines cannot be lengthened by wider spacing between letters. Type design has not yet eliminated the excessive blackness of "ms" and "ws." However, this particular publication is almost free from the last defect.

Apparently before our eyes is appearing a "mutation" or perhaps an emergence" in the process of the printing of scientific journals. It has taken courage to make this start. We commend the men who are sponsoring "Microentomology."

—C. H. K.